TABLE OF CONTENTS

PREFACE

This module is one of a set developed for the Western Alliance for Quality Transportation Construction (WAQTC). WAQTC is an alliance supported by the western state Transportation Departments, along with the Federal Highway Administration (FHWA) and the Western Federal Lands Highway Division (WFLHD) of FHWA. WAQTC's charter includes the following mission.

MISSION

Provide continuously improving quality in transportation construction.

Through our partnership, we will:

- Promote an atmosphere of trust, cooperation, and communication between government agencies and with the private sector.
- Assure personnel are qualified.
- Respond to the requirements of identified needs and new technologies that impact the products that we provide.

BACKGROUND

There are two significant driving forces behind the development of the WAQTC qualification program. One, there is a trend to the use of quality control/quality assurance (QC/QA) specifications. QC/QA specifications include qualification requirements for a contractor's QC personnel and will be requiring WAQTC qualified technicians. Two, Federal regulation on materials sampling and testing (23 CFR 637, *Quality Assurance Procedures for Construction*, published in June 1995) mandates that by June 29, 2000 all testing technicians whose results are used as part of the acceptance decision shall be qualified. In addition, the regulation allows the use of contractor test results to be used as part of the acceptance decision.

OBJECTIVES

WAQTC's objectives for its Transportation Technician Qualification Program include the following:

- To provide highly skilled, knowledgeable materials sampling and testing technicians.
- To promote uniformity and consistency in testing.
- To provide reciprocity for qualified testing technicians between states.
- To create a harmonious working atmosphere between public and private employees based upon trust, open communication, and equality of qualifications.

Training and qualification of transportation technicians is required for several reasons. It will increase the knowledge of laboratory, production, and field technicians — both

industry and agency personnel — and increase the number of available, qualified testers. It will reduce problems associated with test result differences. Regional qualification eliminates the issue of reciprocity between states and allows qualified QC technicians to cross state lines without having the concern or need to be requalified by a different program.

The WAQTC Executive Committee

FORWARD

This module is one of five developed for the Western Alliance for Quality Transportation Construction (WAQTC) by AGRA Earth & Environmental, Inc. (AEE). These modules were developed to satisfy the training requirements prescribed by WAQTC for technicians involved in transportation projects. The five modules cover the areas of:

- Aggregate
- Concrete
- Asphalt
- Embankment and Base
- In-place Density

The modules are based upon AASHTO test methods along with procedures developed by WAQTC. They are narrative in style, illustrated, and include step-by-step instruction. There are review questions at the end of each test procedure, which are intended to reinforce the participants' understanding and help participants prepare for the final written and performance exams. Performance exam check lists are also included. The appendices include the corresponding AASHTO and WAQTC test methods.

Each module is in loose-leaf form. This allows updated and state-specific information to be added, as necessary. It will be the technician's responsibility to stay current as changes are made to this living document.

The comments and suggestions of every participant are essential to the continued success and high standards of the Transportation Technician Qualification Program. Please take the time to fill out the Course Evaluation Form as the course progresses and hand it in on the last day of class. If you need additional room to fully convey your thoughts, please use the back of the form.

The WAQTC Steering Committee

GUIDANCE FOR COURSE EVALUATION FORM

The Course Evaluation Form on the following page is very important to the continuing improvement and success of this course. The form is included in each Participant Workbook. During the course introduction, the Instructor will call the participants' attention to the form, its content, and the importance of its thoughtful completion at the end of the course. Participants will be encouraged to keep notes, or write down comments as the class progresses, in order to provide the best possible evaluation. The Instructor will direct participants to write down comments at the end of each day and to make use of the back of the form if more room is needed for comments.

On the last day of the course, just prior to the written examination, the Instructor will again refer to the form and instruct participants that completion of the form after their last examination is a requirement prior to leaving. Should the course have more than one Instructor, participants should be directed to list them as A, B, etc., with the Instructor's name beside the letter, and direct their answers in the Instructor Evaluation portion of the form accordingly.

WESTERN ALLIANCE FOR QUALITY TRANSPORTATION CONSTRUCTION
COURSE EVALUATION FORM

The WAQTC Transportation Technician Qualification Program would appreciate your thoughtful completion of all items on this evaluation form. Your comments and constructive suggestions will be an asset in our continuing efforts to improve our course content and presentations.

Course Title: _____

Location: _____

Dates: _____

Your Name (Optional): _____

Employer: _____

Instructor(s) _____

COURSE CONTENT

Will the course help you perform your job better and with more understanding? Yes Maybe No

Explain: _____

_____

Was there an adequate balance between theory, instruction, and hands-on application? Yes Maybe No

Explain: _____

_____

Did the course prepare you to confidently complete both examinations? Yes Maybe No

Explain: _____

_____

What was the most beneficial aspect of the course? _____

_____

What was the least beneficial aspect of the course? _____

_____

GENERAL COMMENTS

General comments on the course, content, materials, presentation method, facility, registration process, etc. Include suggestions for additional Tips!

_____

_____

_____

_____

_____

_____

_____

INSTRUCTOR EVALUATION

Were the objectives of the course, and the instructional and exam approach, clearly explained? Yes Maybe No

Explain: _____

_____

Was the information presented in a clear, understandable manner? Yes Maybe No

Explain: _____

_____

Did the instructors demonstrate a good knowledge of the subject? Yes Maybe No

Explain: _____

_____

Did the instructors create an atmosphere in which to ask questions and hold open discussion? Yes Maybe No

Explain: _____

_____

COURSE OBJECTIVES AND SCHEDULE

Learning Objectives

Instructional objectives for this course include:

- Being familiar with Quality Assurance (QA) concepts
- Developing a background in measurements and calculations
- Being knowledgeable in highway materials terminology
- Respecting safety issues
- Acquiring knowledge of random sampling techniques
- Understanding the basics of asphalt
- Becoming proficient in the following quality control test procedures:

  FOP for AASHTO T 168
  Sampling Bituminous Paving Mixtures

  FOP for WAQTC TM 5
  Reducing Samples of Hot Mix Asphalt to Testing Size

  FOP for AASHTO T329
  Moisture Content of Hot Mix Asphalt (HMA) by Oven Method

  FOP for AASHTO T 308
  Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method

  FOP for AASHTO T 209
  Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt Paving Mixtures

  FOP for AASHTO T 166
  Bulk Specific Gravity of Compacted Hot Mix Asphalt Mixtures Using Saturated Surface-Dry Specimens; and
  FOP for AASHTO T 275
  Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens

  FOP for WAQTC TM 8
  In-Place Density of Bituminous Mixes Using the Nuclear Moisture-Density Gauge

  FOP for AASHTO T 40
  Sampling Bituminous Materials

  FOP for AASHTO T 30
  Mechanical Analysis of Extracted Aggregate

The overall goals of this asphalt course are to understand the basics of asphalt and to be competent with specific quality control test procedures identified for the Transportation Technician Qualification Program of the Western Alliance for Quality Transportation Construction (WAQTC). Additional studies beyond this course will be required for those desiring greater in-depth knowledge of the theory behind the test procedures included herein.

Course Outline and Suggested Schedule

Day One

0800	Welcome Introduction of Instructors Introduction and Expectations of Participants
0815	WAQTC Mission and TTQP Objectives Instructional Objectives for the Course Overview of the Course Course Evaluation Form
0830	Review of Quality Assurance Concepts
0845	Background in Measurements and Calculations
0945	Break
1000	Random Sampling
1030	Basics of Asphalt
1045	Sampling Bituminous Paving Mixtures FOP for AASHTO T 168
1115	Reducing Samples of Hot Mix Asphalt to Testing Size FOP for WAQTC TM 5
1130	Review Questions Questions and Answers
1200	Lunch
1315	Moisture Content of Hot Mix Asphalt (HMA) by Oven Method FOP for AASHTO T329

1415	Laboratory Practice Sampling Reducing Moisture Content
1645	Evaluation End of Day

Day Two

0800	Questions from the Previous Day
0815	Determining Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method FOP for AASHTO T 308
0945	Break
1000	Sampling Bituminous Materials FOP for AASHTO T 40
1030	Mechanical Analysis of Extracted Aggregate FOP for AASHTO T 30
1200	Lunch
1315	Laboratory Practice Asphalt Content – Ignition Oven Gradation
1645	Evaluation End of Day

Day Three

0800	Questions from Previous Day
0815	Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt Paving Mixtures FOP for AASHTO T 209
0930	Break

0945	Bulk Specific Gravity of Compacted Hot Mix Asphalt Mixtures Using Saturated Surface-Dry Specimens FOP for AASHTO T 166 Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens FOP for AASHTO T 275
1200	Lunch
1315	Review Questions Questions and Answers
1400	Laboratory Practice Maximum Specific Gravity Bulk Specific Gravity
1645	Evaluation End of day

Day Four

0800	Questions from the Previous Day
815	In-Place Density of Bituminous Mixes Using the Nuclear Moisture-Density Gauge FOP for WAQTC TM 8
0915	Review Questions Questions and Answers
0945	Break
1100	Laboratory Practice Open Lab to Practice Any Procedure
1200	Lunch
1415	Start of Exams Participants will break into groups so that written and performance exams may be given concurrently.

Day Five

0800 Continuation of Exams

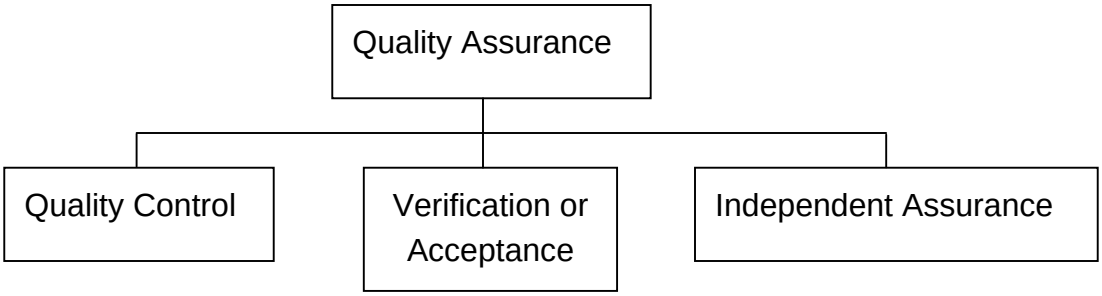
Participants will break into groups so that written and practical exams may be given concurrently.

Evaluation

QUALITY ASSURANCE CONCEPTS

The Federal Highway Administration (FHWA) has established requirements that each State Highway Agency (SHA) must develop a Quality Assurance (QA) Program that is approved by the FHWA for projects on the National Highway System (NHS). In addition to complying with this requirement, implementing QA specifications in a construction program includes the benefit of improvement of overall quality of highway and bridge construction. 01 02

A QA Program may include three separate and distinct parts as illustrated below.



03

Quality Assurance (QA) are those planned and systematic actions necessary to provide confidence that a product or service will satisfy given requirements for quality. 04

Quality Control (QC) are those operational, process control techniques or activities that are performed or conducted to fulfill contract requirements for material and equipment quality. In some states, the constructor is responsible for providing QC sampling and testing, while in other states the SHA handles QC. Where the constructor is responsible for QC tests, the results may be used for acceptance only if verified or accepted by additional tests performed by an independent group. 05

Verification/Acceptance consists of the sampling and testing performed to validate QC sampling and testing and, thus, the quality of the product. Verification/Acceptance samples are obtained and tests are performed independently from those involved with QC. Samples taken for QC tests may not be used for Verification/Acceptance testing. 06

Independent Assurance (IA) are those activities that are an unbiased and independent evaluation of all the sampling and testing procedures used in QC and Verification/Acceptance. IA may use a combination of laboratory certification, technician qualification or certification, proficiency samples, and/or split samples to assure that QC and Verification/Acceptance activities are valid. Agencies may qualify or certify laboratories and technicians, depending on the state in which the work is done. 07

BACKGROUND ON MEASUREMENTS AND CALCULATIONS

01

Introduction

This section provides a background in the mathematical rules and procedures used in making measurements and performing calculations. Topics include:

- Units: Metric vs. English
- Mass vs. Weight
- Balances and Scales
- Rounding
- Significant Figures
- Accuracy and Precision
- Tolerance

Also included is discussion of real-world applications in which the mathematical rules and procedures may not be followed.

02

Units: Metric vs. English

03

The bulk of this document uses dual units. Metric units are followed by Imperial, more commonly known as English, units in parentheses. For example: 25 mm (1 in.). Exams are presented in metric or english.

Basic units in SI include:

Length:	meter, m
Mass:	kilogram, kg
Time:	second, s

Derived units in SI include:

Force:	Newton, N

SI units

04

Depending on the situation, some conversions are exact, and some are approximate. One inch is exactly 25.4 mm. If a procedure calls for measuring to the closest 1/4 in., however, 5 mm is close enough. We do not have to say 6.35 mm. That is because 1/4 in. is half way between 1/8 in. and 3/8 in. – or half way between 3.2 and 9.5 mm. Additionally, the tape measure or rule used may have 5 mm marks, but may not have 1 mm marks and certainly will not be graduated in 6 mm increments.

Metric	English
25 mm	1 in.
1 kg	2.2 lb
1000 kg/m^3	62.4 lb/ft^3
25 MPa	3600 lb/$in.^2$

Some <u>approximate</u> conversions

In SI (Le Systeme International d'Unites), the basic unit of mass is the kilogram (kg) and the basic unit of force, which includes weight, is the Newton (N). Mass in this document is given in grams (g) or kg. See the section below on "Mass vs. Weight" for further discussion of this topic.

Mass vs. Weight

05 The terms mass, force, and weight are often confused. Mass, m, is a measure of an object's material makeup, and has no direction. Force, F, is a measure of a push or pull, and has the direction of the push or pull. Force is equal to mass times acceleration, a.

06

$$F = ma$$

Weight, W, is a special kind of force, caused by gravitational acceleration. It is the force required to suspend or lift a mass against gravity. Weight is equal to mass times the acceleration due to gravity, g, and is directed toward the center of the earth.

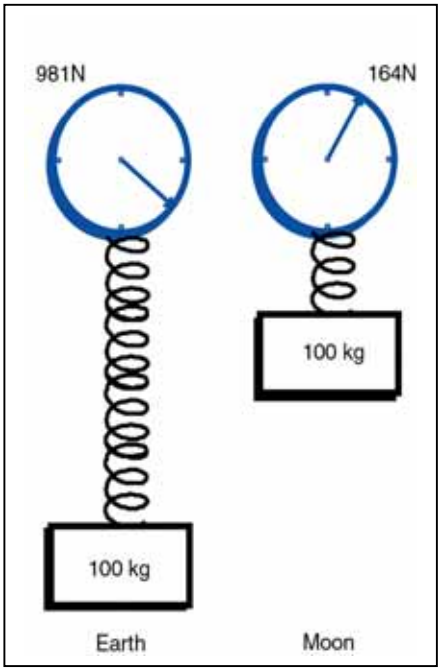
$$W = mg$$

In SI, the basic unit of mass is the kilogram (kg), the units of acceleration are meters per square second (m/s^2), and the unit of force is the Newton (N). Thus a person having a mass of 84 kg subject to the standard acceleration due to gravity, on earth, of 9.81 m/s^2 would have a weight of:

$$W = (84.0\ kg)(9.81\ m/s^2) = 824\ kg\text{-}m/s^2 = 824\ N$$

07 In the English system, mass can be measured in pounds-mass (lb_m), while acceleration is in feet per

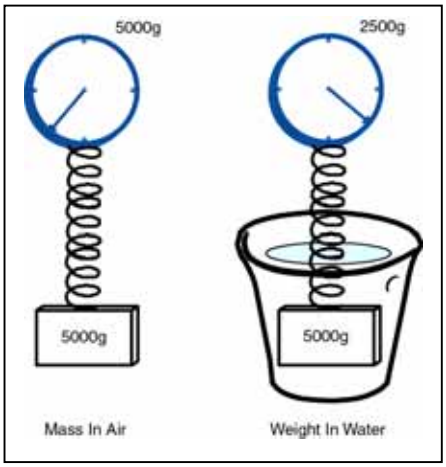
08 square second (ft/s^2), and force is in pounds-force (lb_f). A person weighing 185 lb_f on a scale has a mass of 185 lb_m when subjected to the earth's standard gravitational pull. If this person were to go to the moon, where the acceleration due to gravity is about one-sixth of what it is on earth, the person's weight would be about 31 lb_f, while his or her mass would remain 185 lb_m. Mass does not depend on location, but weight does.



Comparison of mass and weight

While the acceleration due to gravity does vary with position on the earth (latitude and elevation), the variation is not significant except for extremely precise work – the manufacture of electronic memory chips, for example.

As discussed above, there are two kinds of pounds, lb_m and lb_f. In laboratory measurements of mass, the gram or kilogram is the unit of choice. But, is
09 this mass or force? Technically, it depends on the instrument used, but practically speaking, mass is the result of the measurement. When using a scale, force is being measured – either electronically by the stretching of strain gauges or mechanically by the stretching of a spring or other device. When using a balance, mass is being measured, because the mass of the object is being compared to a known mass built into the balance.



Submerged weight

In this document, mass, not weight, is used in test procedures except when determining "weight" in water. When an object is submerged in water (as is done in specific gravity tests), the term weight is used. Technically, what is being measured is the force the object exerts on the balance or scale while the object is submerged in water (or the submerged weight). This force is actually the weight of the object less the weight of the volume of water displaced.

In summary, whenever the common terms "weight"
10 and "weighing" are used, the more appropriate
11 terms "mass" and "determining mass" are usually implied, except in the case of weighing an object submerged in water.

12

Balances and Scales

Balances, technically used for mass determinations, and scales, used to weigh items, were discussed briefly above in the section on "Mass vs. Weight." In field operating procedures, we usually do not differentiate between the two types of instruments. When using either one for a material or object in air, we are determining mass. For those procedures in which the material or object is suspended in water, we are determining weight in water.

13 AASHTO recognizes two general categories of instruments. Standard analytical balances are used in laboratories. For most field operations, general purpose balances and scales are specified. Specifications for both categories are shown in
14 Tables 1 and 2.

Table 1
Standard Analytical Balances

Class	Capacity	Readability and Sensitivity	Accuracy
A	200 g	0.0001 g	0.002 g
B	200 g	0.001 g	0.002 g
C	1200 g	0.01 g	0.02 g

Table 2
General Purpose Balances and Scales

Class	Principal Sample Mass	Readability and Sensitivity	Accuracy
G2	2 kg or less	0.1 g	0.1 g or 0.1 percent
G5	2 kg to 5 kg	1 g	1 g or 0.1 percent
G20	5 kg to 20 kg	5 g	5 g or 0.1 percent
G100	Over 20 kg	20 g	20 g or 0.1 percent

15 ## Rounding

Numbers are commonly rounded up or down after measurement or calculation. For example, 53.67 would be rounded to 53.7 and 53.43 would be rounded to 53.4, if rounding were required. The first number was rounded up because 53.67 is closer to 53.7 than to 53.6. Likewise, the second number was rounded down because 53.43 is closer to 53.4 than to 53.5. The reasons for rounding are covered in the next section on “Significant Figures.”

If the number being rounded ends with a 5, two possibilities exist. In the more mathematically sound approach, numbers are rounded up or down depending on whether the number to the left of the 5 is odd or even. Thus, 102.25 would be rounded down to 102.2, while 102.35 would be rounded up to 102.4. This procedure avoids the bias that would exist if all numbers ending in 5 were rounded up or all numbers were rounded down. In some calculators, however, all rounding is up. This does result in some bias, or skewing of data, but the significance of the bias may or may not be significant to the calculations at hand.

Significant Figures

- General

16 A general purpose balance or scale, classified as G20 in AASHTO M 231, has a capacity of 20,000 g and an accuracy requirement of ±5 g. A mass of 18,285 g determined with such an instrument could actually range from 18,280 g to 18,290 g. Only four places in the measurement are significant. The fifth (last) place is not significant since it may change.

17 Mathematical rules exist for handling significant figures in different situations.
An example in Metric(**m**) or English(**ft**), when performing addition and subtraction, the number of significant figures in the sum or difference is determined by the least precise input. Consider the three situations shown below:

Situation 1	Situation 2	Situation 3
35.67	143.903	162
+ 423.938	- 23.6	+33.546
		- .022
= 459.61	= 120.3	= 196
not 459.608	not 120.303	not 195.524

Rules also exist for multiplication and division. These rules, and the rules for mixed operations involving addition, subtraction, multiplication, and/or division, are beyond the scope of these materials. AASHTO covers this topic to a certain extent in the section called "Precision" or "Precision and Bias" included in many test methods, and the reader is directed to those sections if more detail is desired.

18 • Real World Limitations

While the mathematical rules of significant digits have been established, they are not always followed. For example, AASHTO Method of Test T 176, *Plastic Fines in Graded Aggregates and Soils by the Use of the Sand Equivalent Test*, prescribes a method for rounding and significant digits in conflict with the mathematical rules.

In this procedure, readings and calculated values are always rounded up. A clay reading of 7.94 would be rounded to 8.0 and a sand reading of 3.21 would be rounded to 3.3. The rounded numbers are then used to calculate the Sand Equivalent, which is the ratio of the two numbers multiplied by 100. In this case:

$$\frac{3.3}{8.0} \times 100 = 41.250...,$$

rounded to 41.3 and reported as 42

(Not : $\frac{3.21}{7.94} \times 100 = 40.428...,$

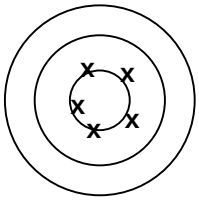
rounded to 40.0 and reported as 40)

It is extremely important that engineers and technicians understand the rules of rounding

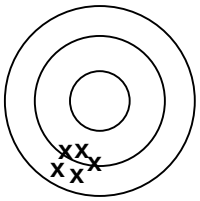
and significant digits just as well as they know procedures called for in standard test methods.

Accuracy and Precision

19 Although often used interchangeably, the terms accuracy and precision do not mean the same thing. In an engineering sense, accuracy denotes nearness to the truth or some value accepted as the truth,
20 while precision relates to the degree of refinement or repeatability of a measurement.



ACCURATE BUT NOT PRECISE, SCATTERED



PRECISE BUT NOT ACCURATE, BIASED

Two bullseye targets are shown to the left. The upper one indicates hits that are scattered and, yet, are very close to the center. The lower one has a tight pattern, but all the shots are biased from the center. The upper one is more accurate, while the lower one is more precise. A biased, but precise, instrument can often be adjusted physically or mathematically to provide reliable single measurements. A scattered, but accurate, instrument can be used if enough measurements are made to provide a valid average.

Consider the measurement of the temperature of boiling water at standard atmospheric pressure by
21 two thermometers. Five readings were taken with each, and the values were averaged.

Thermometer No. 1	Thermometer No. 2
101.2° 214.2°	100.6° 213.1°
101.1° 214.0°	99.2° 210.6°
101.2° 214.2°	98.9° 210.0°
101.1° 214.0°	101.0° 213.8°
101.2° 214.2°	100.3° 212.5°
AVG = 101.2° 214.2°	AVG = 100.0° 212°

No. 1 shows very little fluctuation, but is off the
22 known boiling point (100°C or 212°F) by 1.2°C or 2.2°F. No. 2 has an average value equal to the known boiling point, but shows quite a bit of fluctuation. While it might be preferable to use neither thermometer, thermometer No. 1 could be

employed if 1.2°C or 2.2°F were subtracted from each measurement. Thermometer No. 2 could be
23 used if enough measurements were made to provide a valid average.

24 Engineering and scientific instruments should be calibrated and compared against reference standards periodically to assure that measurements are accurate. If such checks are not performed, the accuracy is uncertain, no matter what the precision. Calibration of an instrument removes fixed error,
25 leaving only random error for concern.

Tolerance

Dimensions of constructed or manufactured objects,
26 including laboratory test equipment, cannot be specified exactly. Some tolerance must be allowed. Thus, procedures for including tolerance in addition/subtraction and multiplication/division operations must be understood.

- Addition and Subtraction

27

When adding or subtracting two numbers that individually have a tolerance, the tolerance of the sum or difference is equal to the sum of the individual tolerances.

An example in Metric(**m**) or English(**ft**), if the distance between two points is made up of two parts, one being 113.361 ±0.006 and the other being 87.242 ±0.005 then the tolerance of the sum (or the difference) is:

(0.006) + (0.005) = 0.011

and the sum would be 200.603 ±0.011.

- Multiplication and Division

28 To demonstrate the determination of tolerance again in either Metric(**m**) or English(**ft**) for the product of two numbers, consider determining the area of a rectangle having sides of 76.254

±0.009 and 34.972 ±0.007. The percentage variations of the two dimensions are:

$$\frac{0.009}{76.254} \times 100 = 0.01\% \qquad \frac{0.007}{34.972} \times 100 = 0.02\%$$

The sum of the percentage variations is 0.03 percent – the variation that is employed in the area of the rectangle:

Area =
2666.8 (m^2 or ft^2) ±0.03 percent = 2666.8 ± 0.8 (m^2 or ft^2).

- Real World Applications

29 Tolerances are used whenever a product is manufactured. For example, the mold used for determining soil density in AASHTO T 99 has a diameter of 101.60 ±0.41 mm(4.000 ±0.016 in) and a height of 116.43 ±0.13 mm(4.584 ±0.005 in).

Using the smaller of each dimension results in a volume of:

$(\pi/4)$ (101.19 mm)^2 (116.30 mm) =
935,287 mm^3 or 0.000935 m^3

$(\pi/4)$ (3.984 in)^2 (4.579 in) =
57.082in^3 or 0.0330 ft^3

Using the larger of each dimension results in a volume of:

$(\pi/4)$ (102.01 mm)^2 (116.56 mm) =
952,631 mm^3 or 0.000953 m^3

$(\pi/4)$ (4.016 in)^2 (4.589 in) =
58.130 in^3 or 0.0336 ft^3

The average value is 0.000944 m^3 (0.0333), and AASHTO T 99 specifies a volume of:

0.000943 ±0.000008 m^3
or a range of
0.000935 to 0.000951 m^3

0.0333 ±0.0003 ft^3
or a range of
0.0330 to 0.0336 ft^3

Because of the variation that can occur, some agencies periodically calibrate molds, and make adjustments to calculated density based on those calculations.

Summary

Mathematics has certain rules and procedures for making measurements and performing calculations that are well established. So are standardized test procedures. Sometimes these agree, but occasionally, they do not. Engineers and technicians must be familiar with both, but must follow test procedures in order to obtain valid, comparable results.

TERMINOLOGY

Many of the terms listed below are defined differently by various agencies or organizations. The definitions of the American Association of State Highway and Transportation Officials (AASHTO) are the ones most commonly used in this document.

Absorbed water – Water drawn into a solid by absorption, and having physical properties similar to ordinary water.

Absorption – The increase in the mass of aggregate due to water being absorbed into the pores of the material, but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry mass.

ACC batch plant – A manufacturing facility for producing asphalt cement concrete (ACC) that proportions aggregate by weight and asphalt by weight or volume.

ACC continuous mix plant – A manufacturing facility for producing asphalt cement concrete (ACC) that proportions aggregate and asphalt by a continuous volumetric proportioning system without specific batch intervals.

Acceptance – See verification.

Acceptance program – All factors that comprise the State Highway Agency's (SHA) determination of the quality of the product as specified in the contract requirements. These factors include verification sampling, testing, and inspection and may include results of quality control sampling and testing.

Admixture – Material other than water, cement, and aggregates in portland cement concrete (PCC).

Adsorbed water – Water attached to the surface of a solid by electrochemical forces, and having physical properties substantially different from ordinary water.

Aggregate – Hard granular material of mineral composition, including sand, gravel, slag or crushed stone, used in roadway base and in portland cement concrete (PCC) and asphalt cement concrete (ACC).

- **Coarse aggregate** – Aggregate retained on or above the 4.75 mm (No. 4) sieve.
- **Coarse-graded aggregate** – Aggregate having a predominance of coarse sizes.
- **Dense-graded aggregate** – Aggregate having a particle size distribution such that voids occupy a relatively small percentage of the total volume.
- **Fine aggregate** – Aggregate passing the 4.75 mm (No. 4) sieve.
- **Fine-graded aggregate** – Aggregate having a predominance of fine sizes.
- **Mineral filler** – A fine mineral product at least 70 percent of which passes a 75 µm (No. 200) sieve.

- **Open-graded gap-graded aggregate** – Aggregate having a particle size distribution such that voids occupy a relatively large percentage of the total volume.
- **Well-Graded Aggregate** – Aggregate having an even distribution of particle sizes.

Aggregate storage bins – Bins that store aggregate for feeding material to the dryer in a hot mix asphalt (HMA) plant in substantially the same proportion as required in the finished mix.

Agitation – Provision of gentle motion in portland cement concrete (PCC) sufficient to prevent segregation and loss of plasticity.

Air voids – Total volume of the small air pockets between coated aggregate particles in asphalt cement concrete (ACC); expressed as a percentage of the bulk volume of the compacted paving mixture.

Ambient temperature – Temperature of the surrounding air.

Angular aggregate – Aggregate possessing well-defined edges at the intersection of roughly planar faces.

Apparent specific gravity – The ratio of the mass, in air, of a volume of the impermeable portion of aggregate to the mass of an equal volume of water.

Asphalt – A dark brown to black cementitious material in which the predominate constituents are bitumens occurring in nature or obtained through petroleum processing. Asphalt is a constituent of most crude petroleums.

Asphalt cement – An asphalt specially prepared in quality and consistency for use in the manufacture of asphalt cement concrete (ACC).

Asphalt cement concrete (ACC) – A controlled mix of aggregate and asphalt cement.

Automatic cycling control – A control system in which the opening and closing of the weigh hopper discharge gate, the bituminous discharge valve, and the pugmill discharge gate are actuated by means of automatic mechanical or electronic devices without manual control. The system includes preset timing of dry and wet mixing cycles.

Automatic dryer control – A control system that automatically maintains the temperature of aggregates discharged from the dryer.

Automatic proportioning control – A control system in which proportions of the aggregate and asphalt fractions are controlled by means of gates or valves that are opened and closed by means of automatic mechanical or electronic devices without manual control.

Bag (of cement) – 94 lb of portland cement. (Approximately 1 ft^3 of bulk cement.)

Base – A layer of selected material constructed on top of subgrade or subbase and below the paving on a roadway.

Bias – The offset or skewing of data or information away from its true or accurate position as the result of systematic error.

Binder – Asphalt cement or modified asphalt cement that binds the aggregate particles into a dense mass.

Boulders – Rock fragment, often rounded, with an average dimension larger than 300 mm (12 in.).

Bulk specific gravity – The ratio of the mass, in air, of a volume of aggregate or compacted HMA mix (including the permeable and impermeable voids in the particles, but not including the voids between particles) to the mass of an equal volume of water.

Bulk specific gravity (SSD) – The ratio of the mass, in air, of a volume of aggregate or compacted HMA mix, including the mass of water within the voids (but not including the voids between particles), to the mass of an equal volume of water. (See saturated surface dry.)

Cementitous Materials – cement and pozzolans used in concrete such as; Portland Cement, fly ash, silica fume, & blast-furnace slag.

Clay – Fine-grained soil that exhibits plasticity over a range of water contents, and that exhibits considerable strength when dry. Also, that portion of the soil finer than 2 µm.

Cobble – Rock fragment, often rounded, with an average dimension between 75 and 300 mm (3 and 12 in.).

Cohesionless soil – Soil with little or no strength when dry and unconfined or when submerged, such as sand.

Cohesive soil – Soil with considerable strength when dry and that has significant cohesion when unconfined or submerged.

Compaction – Densification of a soil or hot mix asphalt (HMA) by mechanical means.

Compaction curve (Proctor curve or moisture-density curve) – The curve showing the relationship between the dry unit weight or density and the water content of a soil for a given compactive effort.

Compaction test (moisture-density test) – Laboratory compaction procedure in which a soil of known water content is placed in a specified manner into a mold of given dimensions, subjected to a compactive effort of controlled magnitude, and the resulting density determined.

Compressibility – Property of a soil or rock relating to susceptibility to decrease in volume when subject to load.

Constructor – The builder of a project. The individual or entity responsible for performing and completing the construction of a project required by the contract documents. Often called a contractor, since this individual or entity contracts with the owner.

Crusher-run – The total unscreened product of a stone crusher.

Delivery tolerances – Permissible variations from the desired proportions of aggregate and asphalt cement delivered to the pugmill.

Density – The ratio of mass to volume of a substance. Usually expressed in kg/m^3.

Design professional – The designer of a project. This individual or entity may provide services relating to the planning, design, and construction of a project, possibly including materials testing and construction inspection. Sometimes called a "contractor", since this individual or entity contracts with the owner.

Dryer – An apparatus that dries aggregate and heats it to specified temperatures.

Dry mix time – The time interval between introduction of aggregate into the pugmill and the addition of asphalt cement.

Durability – The property of concrete that describes its ability to resist disintegration by weathering and traffic. Included under weathering are changes in the pavement and aggregate due to the action of water, including freezing and thawing.

Effective diameter (effective size) – D_{10}, particle diameter corresponding to 10 percent finer or passing.

Embankment – Controlled, compacted material between the subgrade and subbase or base in a roadway.

End-result specifications – Specifications that require the Constructor to take the entire responsibility for supplying a product or an item of construction. The Owner's (the highway agency's) responsibility is to either accept or reject the final product or to apply a price adjustment that is commensurate with the degree of compliance with the specifications. Sometimes called performance specifications, although considered differently in highway work. (See performance specifications.)

Field operating procedure (FOP) – Procedure used in field testing on a construction site or in a field laboratory. (Based on AASHTO or NAQTC test methods.)

Fineness modulus – A factor equal to the sum of the cumulative percentages of aggregate retained on certain sieves divided by 100; the sieves are 150, 75, 37.5, 19.0, 9.5, 4.75, 2.36, 1.18, 0.60, 0.30, and 0.15 mm. Used in the design of concrete mixes. The lower the fineness modulus, the more water/cement paste that is needed to coat the aggregate.

Fines – Portion of a soil or aggregate finer than a 75 μm (No. 200) sieve. Also silts and clays.

Free water – Water on aggregate available for reaction with hydraulic cement. Mathematically, the difference between total moisture content and absorbed moisture content.

Glacial till – Material deposited by glaciation, usually composed of a wide range of particle sizes, which has not been subjected to the sorting action of water.

Gradation (grain-size distribution) – The proportions by mass of a soil or fragmented rock distributed by particle size.

Gradation analysis (grain size analysis or sieve analysis) – The process of determining grain-size distribution by separation of sieves with different size openings.

Hot aggregate storage bins – Bins that store heated and separated aggregate prior to final proportioning into the mixer.

Hot mix asphalt (HMA) – High quality, thoroughly controlled hot mixture of asphalt cement and well-graded, high quality aggregate.

Hydraulic cement – Cement that sets and hardens by chemical reaction with water.

Independent assurance – Unbiased and independent evaluation of all the sampling and testing procedures, equipment, and technicians involved with Quality Control (QC) and Verification/Acceptance.

In situ – Rock or soil in its natural formation or deposit.

Liquid limit – Water content corresponding to the boundary between the liquid and plastic states.

Loam – A mixture of sand, silt and/or clay with organic matter.

Lot – A quantity of material to be controlled. It may represent a specified mass, a specified number of truckloads, or a specified time period during production.

Manual proportioning control – A control system in which proportions of the aggregate and asphalt fractions are controlled by means of gates or valves that are opened and closed by manual means. The system may or may not include power assisted devices in the actuation of gate and valve opening and closing.

Materials and methods specifications – Also called prescriptive specifications. Specifications that direct the Constructor to use specified materials in definite proportions and specific types of equipment and methods to place the material.

Maximum size – One sieve larger than nominal maximum size.

Mesh – The square opening of a sieve.

Moisture content – The ratio, expressed as a percentage, of the mass of water in a material to the dry mass of the material.

Nominal maximum size – One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

Note: - The first sieve to normally retain more than 10% of the material usually is the second sieve in the stack but may be the third sieve.

Nuclear gauge – Instruments used to measure in-place density, moisture content, or asphalt content through the measurement of nuclear emissions.

Optimum moisture content (optimum water content) – The water content at which a soil can be compacted to a maximum dry density by a given compactive effort.

Organic soil – Soil with a high organic content.

Owner – The organization that conceives of and eventually operates and maintains a project. A State Highway Agency (SHA) is an Owner.

Paste – Mix of water and hydraulic cement that binds aggregate in portland cement concrete (PCC).

Penetration – The consistency of a bituminous material, expressed as the distance in tenths of a millimeter (0.1 mm) that a standard needle vertically penetrates a sample of the material under specified conditions of loading, time, and temperature.

Percent compaction – The ratio of density of a soil, aggregate, or HMA mix in the field to maximum density determined by a standard compaction test, expressed as a percentage.

Performance specifications – Specifications that describe how the finished product should perform. For highways, performance is typically described in terms of changes over time in physical condition of the surface and its response to load, or in terms of the cumulative traffic required to bring the pavement to a condition defined as "failure." Specifications containing warranty/guarantee clauses are a form of performance specifications.

Plant screens – Screens located between the dryer and hot aggregate storage bins that separate the heated aggregates by size.

Plastic limit – Water content corresponding to the boundary between the plastic and the semisolid states.

Plasticity – Property of a material to continue to deform indefinitely while sustaining a constant stress.

Plasticity index – Numerical difference between the liquid limit and the plastic limit and, thus, the range of water content over which the soil is plastic.

Portland cement – Hydraulic cement produced by pulverizing portland cement clinker.

Portland cement concrete (PCC) – A controlled mix of aggregate, portland cement, and water, and possibly other admixtures.

PCC batch plant – A manufacturing facility for producing portland cement concrete.

Prescriptive specifications – See Materials and Methods specification.

Proficiency samples – Homogeneous samples that are distributed and tested by two or more laboratories. The test results are compared to assure that the laboratories are obtaining the same results.

Pugmill – A shaft mixer designed to mix aggregate and cement.

Quality assurance – Planned and systematic actions necessary to provide confidence that a product or service will satisfy given requirements for quality. The overall system for providing quality in a constructed project, including Quality Control (QC), Verification/Acceptance, and Independent Assurance (IA).

Quality assurance specifications – Also called QC/QA specifications. A combination of end-result (performance) specifications and materials and methods (prescriptive) specifications. The Constructor is responsible for quality control, and the Owner (highway agency) is responsible for acceptance of the product.

Quality control (QC) – Operational, process control techniques or activities that are performed or conducted to fulfill contract requirements for material or equipment quality.

Random sampling – Procedure for obtaining non-biased, representative samples.

Sand – Particles of rock passing the 4.75 mm (No. 4) sieve and retained on the 75 µm (No. 200) sieve.

Saturated surface dry (SSD) – Condition of an aggregate particle, asphalt cement concrete (ACC) or portland cement concrete (PCC) core, or other porous solid when the permeable voids are filled with water, but no water is present on exposed surfaces. (See bulk specific gravity.)

Segregation – The separation of aggregate by size resulting in a non-uniform material.

SHRP – The Strategic Highway Research Program (SHRP) established in 1987 as a five-year research program to improve the performance and durability of roads and to make those roads safe for both motorists and highway workers. SHRP research funds were partly used for the development of performance-based specifications to directly relate laboratory analysis with field performance.

Sieve – Laboratory apparatus consisting of wire mesh with square openings, usually in circular or rectangular frames.

Silt – Material passing the 75 µm (No. 200) sieve that is non-plastic or very slightly plastic, and that exhibits little or no strength when dry and unconfined. Also, that portion of the soil finer than 75 µm and coarser than 2 µm.

Slump – Measurement related to the workability of concrete.

Soil – Sediments or unconsolidated accumulations of solid particles produced by the physical and chemical disintegration or rocks, and which may or may not contain organic matter.

Specific gravity – The ratio of the mass, in air, of a volume of a material to the mass of an equal volume of water.

Stability – The ability of an asphalt cement concrete (ACC) to resist deformation from imposed loads. Stability is dependent upon internal friction, cohesion, temperature, and rate of loading.

Stratified random sampling – Procedure for obtaining non-biased, representative samples in which the established lot size is divided into equally-sized sublots.

Subbase – A layer of selected material constructed between the subgrade and the base coarse in a flexible HMA roadway, or between the subgrade and portland cement concrete (PCC) pavement in a rigid PCC roadway.

Subgrade – Natural soil prepared and compacted to support a structure or roadway pavement.

Sublot – A segment of a lot chosen to represent the total lot.

Superpave™ – Superpave™ (Superior Performing Asphalt Pavement) is a trademark of the Strategic Highway Research Program (SHRP). Superpave™ is a product of the SHRP asphalt research. The Superpave™ system incorporates performance-based asphalt materials characterization with design environmental conditions to improve performance by controlling rutting, low temperature cracking and fatigue cracking. The three major components of Superpave™ are the asphalt binder specification, the mix design and analysis system, and a computer software system.

Theoretical maximum specific gravity – The ratio of the mass of a given volume of asphalt cement concrete (ACC) with no air voids to the mass of an equal volume of water, both at a stated temperature.

Topsoil – Surface soil, usually containing organic matter.

Uniformity coefficient – C_u, a value employed to quantify how uniform or well-graded an aggregate is: $C_u = D_{60}/D_{10}$. 60 percent of the aggregate, by mass, has a diameter smaller than D_{60} and 10 percent of the aggregate, by mass, has a diameter smaller than D_{10}.

Unit weight – The ratio of weight to volume of a substance. The term “density” is more commonly used.

µm – Micro millimeter (micron) Used as measurement for sieve size.

Vendor – Supplier of project-produced material that is other than the constructor.

Verification – Process of sampling and testing performed to validate Quality Control (QC) sampling and testing and, thus, the quality of the product. Sometimes called Acceptance.

Viscosity – A measure of the resistance to flow; one method of measuring the consistency of asphalt.

- **Absolute viscosity** – A method of measuring viscosity using the "poise" as the basic measurement unit. This method is used at a temperature of 60°C, typical of hot pavement.

- **Kinematic viscosity** – A method of measuring viscosity using the stoke as the basic measurement unit. This method is used at a temperature of 135°C, typical of hot asphalt at a plant.

Void in the mineral aggregate (VMA) – The volume of inter-granular void space between aggregate particles of compacted asphalt cement concrete (ACC) that includes air and asphalt; expressed as a percentage of the bulk volume of the compacted paving mixture.

Voids filled with asphalt – The portion of the void in the mineral aggregate (VMA) that contains asphalt; expressed as a percentage of the bulk volume of mix or the VMA.

Wet mixing period – The time interval between the beginning of application of asphalt material and the opening of the mixer gate.

Zero air voids curve (saturation curve) – Curve showing the zero air voids density as a function of water content.

SAFETY

The procedures included in this manual may involve hazardous materials, operations, and equipment. The procedures do not address all of the safety issues associated with their use. It is the responsibility of the employer to assess workplace hazards and to determine whether personal protective equipment (PPE) must be used. PPE must meet applicable American National Standards Institute (ANSI) standards, and be properly used and maintained. The employer must establish appropriate safety and health practices, in compliance with applicable state and federal laws, for these procedures and associated job site hazards. Hazardous materials must be addressed in a Hazard Communication program, and Material Safety Data Sheets (MSDS) must be obtained and available to workers. Supervisors and employees should be aware of job site hazards, and comply with their employers safety and health program. The following table identifies some areas that may affect individuals performing the procedures in this manual.

Body Part Affected	Potential Hazards	PPE/Procedures That May Be Appropriate
Head	Falling or fixed overhead objects; electrical shock	Hard hat or other protective helmet
Eyes and Face	Flying objects, radiation, molten metal, chemicals	Safety glasses, goggles, face shields; prescription or filter lenses
Ears	Noise	Ear plugs, ear muffs
Respiratory System	Inhalation of dusts, chemicals; O_2 deficiency	Properly fit and used respiratory protection consistent with the hazard
Skin	Chemicals including cement; heat	Appropriate chemical or heat resistant gloves, long-sleeve shirts, coveralls
Mouth, digestive system	Ingestion of toxic materials	Disposable or washable gloves, coveralls; personal hygiene
Hands	Physical injury (pinch, cut, puncture), chemicals	Appropriate gloves for physical hazards and compatible with chemicals present
Feet	Falling, sharp objects; slippery surfaces, chemicals	Safety shoes or boots (steel toed, steel shank); traction soles; rubber boots – chemicals, wet conditions
Joints, muscles, tendons	Lifting, bending, twisting, repetitive motions	Proper training and procedures; procedure modifications
Body/Torso	Falls; Burial	Fall protection; trench sloping or shoring
Miscellaneous	Traffic	Visibility, awareness, communication; driver training, safety awareness
Whole body	Radiation	Radiation safety training

RANDOM SAMPLING OF CONSTRUCTION MATERIALS

Significance

01 Sampling and testing are two of the most important functions in quality control (QC). Data from the tests are the tools with which the quality of product is controlled. For this reason, great care must be used in following standardized sampling and testing procedures.

In controlling operations, it is necessary to obtain numerous samples at various points along the production line. Unless precautions are taken, sampling can occur in patterns that can create a bias to the data gathered. Sampling at the same time, say noon, each day may jeopardize the effectiveness of any quality program. This might occur, for example, because a material producer does certain operations, such as cleaning screens at an aggregate plant, late in the morning each day. To obtain a representative sample, a reliable system of random sampling must be employed.

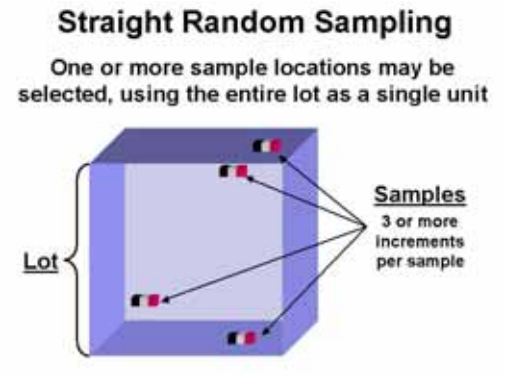
02

Scope

The procedure presented here eliminates bias in sampling materials. Randomly selecting a set of
03 numbers from a table or calculator will eliminate
04 the possibility for bias. Random numbers are used to identify sampling times, locations, or points within a lot or sublot. This method does not cover how to sample, but rather how to determine sampling times, locations, or points.

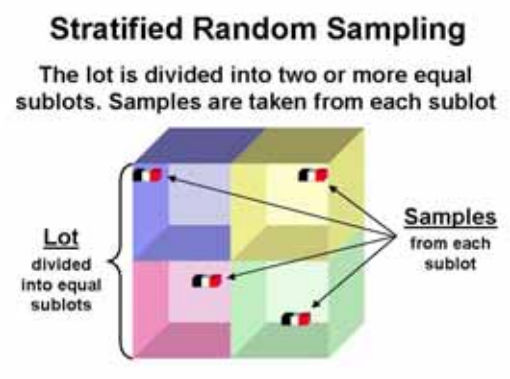
Sampling Concepts

A lot is the quantity of material evaluated by QC
05 procedures. A lot is a preselected quantity that may represent hours of production, a quantity or number of loads of material, or an interval of time.



A lot may be comprised of several portions that are called sublots or units. The number of sublots comprising a lot will be determined by the agency's specifications.

06 **Straight Random Sampling vs. Stratified Random Sampling:** Straight random sampling considers an entire lot as a single unit and determines each sample location based on the entire lot size. Stratified random sampling divides the lot into a specified number of sublots or units and then determines each sample location within a distinct sublot. Both methods result in random distribution of samples to be tested for compliance with the agency's specification.



07 Agencies stipulate when to use straight random sampling or stratified random sampling. AASHTO T 2, Sampling of Aggregates, for example, specifies a straight random sampling procedure.

Picking Random Numbers from a Table

08 Table 1 contains pairs of numbers. The first number is the "pick" number and the second is the Random Number, "RN". The table was generated with a spreadsheet and the cells (boxes at the intersection of rows and columns) containing the RNs actually contain the "random number function". Every time the spreadsheet is opened or changed, all the RNs change.

1. Select a Pick number in a random method. The first two or last two digits in the next automobile license plate you see would be one way to select. Another would be to start a digital stop watch and stop it several seconds later, using the decimal part of the seconds as your Pick number.
2. Find the RN matching the Pick number.

Picking Random Numbers with a Calculator

09 Many calculators have a built-in random number function. To obtain a random number, key in the code or push the button(s) the calculator's instructions call for. The display will show a number between 0.000 and 1.000 and this will be your random number.

TABLE 1
Random Numbers

Pick	RN	Pick	RN	Pick	RN	Pick	RN	Pick	RN
01	0.998	21	0.758	41	0.398	61	0.895	81	0.222
02	0.656	22	0.552	42	0.603	62	0.442	82	0.390
03	0.539	23	0.702	43	0.150	63	0.821	83	0.468
04	0.458	24	0.217	44	0.001	64	0.187	84	0.335
05	0.407	25	0.000	45	0.521	65	0.260	85	0.727
06	0.062	26	0.781	46	0.462	66	0.815	86	0.708
07	0.370	27	0.317	47	0.553	67	0.154	87	0.161
08	0.410	28	0.896	48	0.591	68	0.007	88	0.893
09	0.923	29	0.848	49	0.797	69	0.759	89	0.255
10	0.499	30	0.045	50	0.638	70	0.925	90	0.604
11	0.392	31	0.692	51	0.006	71	0.131	91	0.880
12	0.271	32	0.530	52	0.526	72	0.702	92	0.656
13	0.816	33	0.796	53	0.147	73	0.146	93	0.711
14	0.969	34	0.100	54	0.042	74	0.355	94	0.377
15	0.188	35	0.902	55	0.609	75	0.292	95	0.287
16	0.185	36	0.674	56	0.579	76	0.854	96	0.461
17	0.809	37	0.509	57	0.887	77	0.240	97	0.703
18	0.105	38	0.013	58	0.495	78	0.851	98	0.866
19	0.715	39	0.497	59	0.039	79	0.678	99	0.616
20	0.380	40	0.587	60	0.812	80	0.122	00	0.759

Examples of Straight Random Sampling Procedures Using Random Numbers

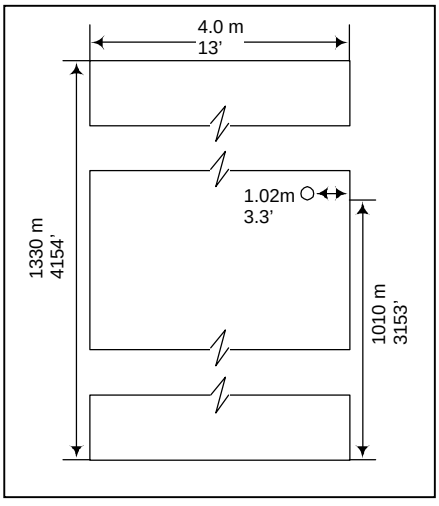
10 **Sampling from a Belt or Flowing Stream:** Agencies specify the frequency of sampling in terms of time, volumes, or masses. The specification might call for one sample from every 1,000,000 kg(1000 t) or 1100 Tons(T) of aggregate. If the random number was 0.317, the

sample would be taken at (0.317)(1,000,000 kg) = 317,000 kg (317 t). Or (.317) (1100 T) = 349 T.

One sample per day might also be specified. If the day were 9 hours long and the random number 0.199, the sample would be taken at (0.199)(9 hrs) = 1.79 hr = 1 hr, 48 minutes into the day. AASHTO T 2 permits this time to be rounded to the nearest 5 minutes.

11 **Sampling from Haul Units:** Based on the agency's specifications – in terms of time, volume, or mass – determine the number of haul units that comprise a lot. Multiply the selected random number(s) by the number of units to determine which unit(s) will be sampled.

For example, if 20 haul units comprise a lot and one sample is needed, pick one RN. If the RN were 0.773, then the sample would be taken from the (0.773) (20) = 15.46, or 16th haul unit.



Sampling from a roadway

12 **Sampling from a Roadway with Previously Placed Material:** The agency's specified frequency of sampling – in time, volume, or mass – can be translated into a location on a job. For example, if a sample is to be taken every 800 m^3 (1000yd^3) and material is being placed 0.15 m (0.50') thick and 4.0 m (13') wide, then the lot is 1330 m (4154') long. You would select two RNs in this case. To convert yd^3 to ft^3 multiply by 27.

13 The first RN would be multiplied by the length to determine where the sample would be taken along the project. The second would be multiplied by the width to determine where, widthwise, the sample would be taken. For example, a first RN of 0.759 would specify that the sample would be taken at (0.759)(1330 m) or (4154') = 1010 m or 3153'from the beginning. A second RN of 0.255 would specify that the sample would be taken at (0.255)(4.0 m) or (13') = 1.02 m or 3.3'from the

14

15

right edge of the material. To avoid problems associated with taking samples too close to the edge, no sample is taken closer than 0.3 m (1') to the edge. If the RN specifies a location closer than 0.3 m (1'), then 0.3 m (1') is added to or subtracted from the distance calculated.

16 **Sampling from a Stockpile:** AASHTO T 2 recommends against sampling from stockpiles. However, some agencies use random procedures in determining sampling locations from a stockpile. Bear in mind that stockpiles are prone to segregation and that a sample obtained from a stockpile may not be representative. Refer to AASHTO T 2 for guidance on how to sample from a stockpile.

17 **In-Place Density Testing:** Agency specifications will indicate the frequency of tests. For example, one test per 500 m^3 (666 yd^3) might be required. If the material is being placed 0.15 m (0.50') thick and 10.0 m (33') wide, then the lot is 333 m (1090') long. You would select two RNs in this case.

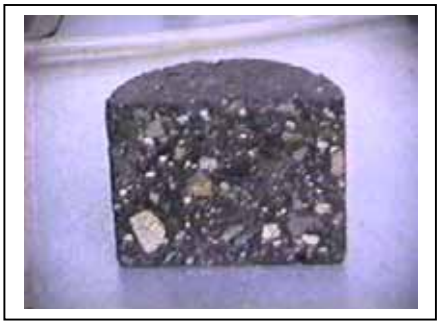
18 The first RN would be multiplied by the length to determine where the sample would be taken along the project. The second would be multiplied by the width to determine where, widthwise, the sample would be taken. For example, a first RN of 0.387 would specify that the sample would be taken at (0.387)(333 m) or (1090') = 129 m or (422') from the beginning. A second RN of 0.588 would specify that the sample would be taken at (0.588)(10.0 m) or (33') = 5.88 m or (19') from the

19 right edge of the material. To avoid problems associated with taking samples too close to the edge, no sample is taken closer than 0.3 m (1') to the edge. If the RN specifies a location closer than 0.3 m (1'), then 0.3 m (1') is added to or subtracted from the distance calculated.

BASICS OF ASPHALT

01

Introduction

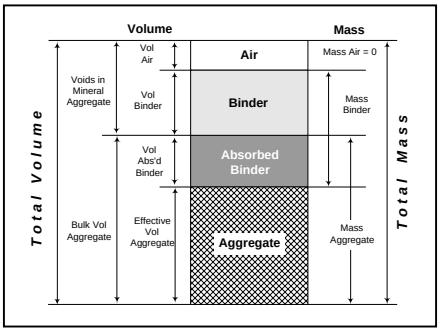


Slice through asphalt core

02 Asphalt cement concrete (ACC) is a mixture of two primary ingredients: mineral aggregate and asphalt cement (AC) or asphalt binder as it is now termed. The binder holds the aggregate together in a moderately flexible rock-like mass. Hot mix

03 asphalt (HMA) includes mixes that are produced at an elevated temperature. ACC and HMA are generally divided into three types of mixes, depending on the gradation of aggregate: dense-graded, open-graded, and gap-graded.

04 Dense-graded HMA consists of binder and well-graded aggregate evenly distributed from small to large particles. Open-graded HMA consists primarily of coarse aggregate, minimal fine aggregate, and binder. The mixture provides a very open surface texture — one that allows water to drain into the mix and in which large aggregate, stone-to-stone contact handles the load of a vehicle traveling over the surface. Gap-graded HMA is similar to open-graded mix, except that mid-size aggregate between the 4.75 mm (No. 4) and 425 µm (No. 40) sieves is missing or present only in small amounts.



HMA phase diagram

HMA contains air voids in addition to aggregate and binder. Also, the binder is divided into two

05 categories: absorbed (into the aggregate) and effective (which remains on the surface for binding aggregate particles together).

06 Five factors affect pavement performance: structural design of pavement layers, mix design properties, workmanship used to produce, place, and compact the mix, loading factors, and environmental conditions. The best specifications, if not followed, will not assure a high quality, long-lasting pavement. The best mix design, if not duplicated at the plant, will not guarantee the life of the pavement. The most sophisticated equipment, if not operated properly, will not produce a roadway that withstands the effects of traffic and the environment. Poor workmanship can negate all

those items and cause premature failure of pavement materials and/or pavement structure. High quality materials testing and construction inspection are critical to a successful project.

Design Parameters

Whether a mix design is developed through a
07 Marshall, Hveem, or Superpave mix design process there are basic volumetric requirements of all. Volumetrics can include Bulk specific gravity,
08 theoretical maximum specific gravity, air voids, and voids in mineral aggregate.
09

The total mass of the mix includes entrapped air, moisture, effective and absorbed binder, and mineral aggregate. This total mass divided by the corresponding bulk or total volume of a specimen yields a number known as bulk density. Bulk density is calculated by determining the bulk specific gravity, G_{mb}, of the sample and multiplying by the density of water.

- Specific gravity is the ratio of the density of a material to the density of water, 1000 kg/m^3 (62.4 lb/ft^3).

There are two procedures for calculating G_{mb} –
10 suspension and volumeter. In the suspension procedure, G_{mb} is calculated as follows.

$$G_{mb} = \frac{A}{B - C}$$

where:

G_{mb} = Bulk specific gravity
A = Mass of dry, compacted specimen in air
B = Mass of saturated surface dry (SSD) compacted specimen in air
C = Weight of compacted specimen in water at 25°C (77°F)

The combined masses of binder and aggregate
11 divided by the volume of these components only is the maximum density. This density is “maximum” in that it contains no air voids. The maximum density provides a reference or base used to determine the amount of air actually present in the

mix, among other things. Maximum density is determined on uncompacted HMA by determining the theoretical maximum specific gravity, G_{mm}, and multiplying by the density of water.

12 There are two procedures for calculating G_{mm} – bowl and flask. In the flask procedure, G_{mm} is calculated as follows.

$$G_{mm} = \frac{A}{A + D - E}$$

where:

G_{mm} = Theoretical maximum specific gravity
A = Mass of dry specimen in air
D = Mass of flask filled with water at 25°C (77°F)
E = Mass of flask filled with water and specimen at 25°C (77°F)

13 Air voids are expressed as a percentage of total sample volume. Percent air voids, V_a, is calculated as follows.

$$V_a = ((G_{mm} - G_{mb})/G_{mm}) \times 100$$

where:

V_a = Percent air voids of total mix mass
G_{mb} = Bulk specific gravity of compacted mix
G_{mm} = Theoretical maximum specific gravity

14 Voids between aggregate particles may contain air or binder. Voids in the mineral aggregate, VMA, are those spaces in laboratory compacted specimens that include air and effective, but not absorbed, binder.

15

$$VMA = 100 - \left[\frac{(G_{mb} P_s)}{G_{sb}}\right]$$

where:

VMA = Voids in the mineral aggregate
G_{mb} = Bulk specific gravity of compacted mix
G_{sb} = Bulk specific gravity of aggregate

P_s = Percent aggregate content in mix by mass of total mix

16 Finally, the voids filled with asphalt (VFA) is expressed as the percentage of the VMA that contains asphalt.

$$VFA = ((VMA - V_a) / VMA) \times 100$$

where:

VFA = Voids filled with asphalt
VMA = Voids in the mineral aggregate
V_a = Percent air voids by total mass of mix

The above parameters are used in developing HMA mix design. These items should be systematically monitored during construction to ensure a quality product.

Asphalt Cement Binder

17 In the past, asphalt cement (AC) was graded by either penetration (AASHTO M 20) or viscosity (AASHTO M 226). Penetration graded asphalts were specified by a measurement by a standardized penetrometer needle under a standard load at a standard temperature. Penetration graded asphalts were typically expressed as "Penetration Grade 85-100", meaning that the needle penetration was between 85 and 100 millimeters. The higher the penetration, the softer the AC.

Viscosity graded asphalts were specified by determining the viscosity of AC. A temperature of 60°C (140°F) was considered to be a typical summer pavement temperature, and at this temperature, the unit of viscosity used was the poise. Standard terminology referred to AC-10 and AC-20, meaning that the viscosity of the AC was 1000 or 2000 poise, respectively. AC-20 was thicker or harder than AC-10. A temperature of 135°C (275°F) was considered the mixing and handling control point. At this temperature,

different laboratory equipment was used and the unit of viscosity used was the centistoke (Cs).

In 1994, the industry formally accepted and began to implement years of research done under the Strategic Highway Research Program (SHRP). SHRP developed a new system of design for asphalt paving materials known as Superpave™. A new concept calling for performance grading was introduced.

18 Performance Graded (PG) asphalt binders were introduced experimentally in 1994 and industry now uses PG specifications. The PG system of specifying binder is based on a complex series of performance based tests. The new specification system no longer refers to asphalt cement, but rather to binder, which includes modified and unmodified asphalts.

The new system specifies asphalt binders as PG followed by two numbers, for example PG 64-22. The first number is always higher and positive, while the second number is smaller and negative. The first number represents the expected average 7-day high pavement temperature, while the second number represents the expected single low pavement temperature. Both numbers referred to are in degrees Celsius.

Types of Manufacturing Plants

19 Two common types of plants are drum plants and batch plants. Both types are capable of producing the same quality HMA. One is not better than the other. These plants are similar in that both have cold feed systems for aggregate. Material of different sizes is dropped from bins onto belts, transported to a mixer, blended, and then dropped onto another belt for transport to the dryer. The plants are different in the means of production following heating in the dryer.

Aggregate feed bins

20 **Drum Plants** – In drum plants, scales under the belts from each bin control the mass flow rate of
21 each aggregate size. Moisture corrections are applied in order to base the process on dry mass. Binder flow rate is controlled by a metered delivery

pump. Aggregate and binder are mixed in the far end (near the exit) of the drum and then stored temporarily in a silo.

With a drum plant supplying HMA to a single project, the aggregate and binder, as measured by the scales and meter, can be compared with the material delivered to the job. After accounting for waste and reject, binder quantity, as measured by field tests, should agree within 1 percent with the quantity metered at the plant. The total mass of the aggregate and binder measured at the plant should agree within 2 percent of total mass delivered to the site as measured by the platform scales over which the delivery trucks pass.

Drum plants are typically used for large jobs and are more portable. Drum plants continuously feed aggregate and binder into the drum, and produce large quantities of HMA during the course of a run. Drum plants, however, cannot switch mix designs with ease and require close control of material being fed to the dryer. Drum plants produce the same mix over an extended period, not several different mixes in a day as with batch plants.

Aggregate feed

22

Batch Plants – In batch plants, aggregate is rescreened and stored in separate bins after drying. Aggregate is taken from each bin on the basis of the mass called for in the mix design – the mass being determined in the aggregate hopper. A separate hopper is used for determining the mass of the binder. Aggregate and binder are mixed in a chamber, or pugmill, and then dropped into a truck or stored temporarily in a silo.

Batch plants are used where different mix designs are often needed. Batch plants are less efficient than drum plants because they only mix a certain amount of HMA at a time. They are more flexible, however, because several mixes can be made in a day. In fact, a batch plant can switch from one mix to another fairly quickly, as long as both mixes use aggregates from the same source.

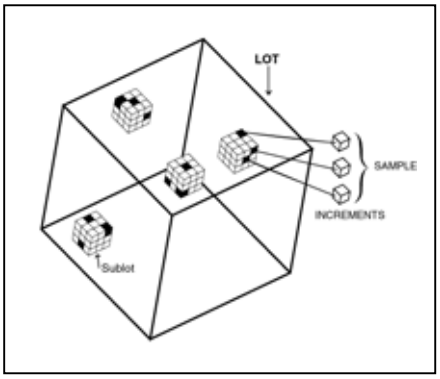
Summary

23

High quality hot mix asphalt requires a proper

combination of materials and workmanship. The testing technician plays a critical role in helping assure that materials incorporated into a roadway meet the requirements of the proper specification. No amount of proper workmanship can compensate for poor material quality.

SAMPLING OF BITUMINOUS PAVING MIXTURES
FOP FOR AASHTO T 168



Sampling from a lot

01

Significance

Testing bituminous paving mixtures in the field begins with obtaining and preparing the sample to be tested. Standardized procedures for obtaining a representative sample have been established. Producing strong, durable, reliable pavement in roadways requires careful sampling and accurate testing.

Technicians must be patient and follow these procedures. If one considers that the specifications require quality tests to be made on only a small portion of the total material placed, the need for a truly representative sample is apparent.

02

HMA sample

03

Scope

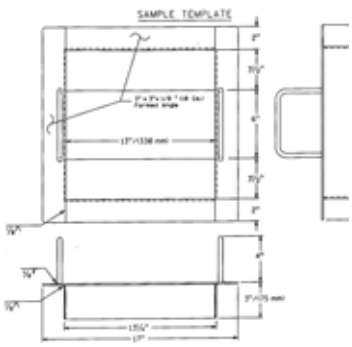
This procedure covers the sampling of bituminous paving mixtures from HMA plants; haul units, and roadways, in accordance with AASHTO T 168.

Sampling is as important as testing, and every precaution must be taken to obtain a truly representative sample.

04

Apparatus

- Shovel
- Sample containers: such as cardboard boxes, metal cans, stainless steel bowls, or other agency-approved containers
- Belt template to match conveyor belt shape
- Scoops, trowels, or other equipment to obtain mix
- Sampling plate: heavy gauge metal plate 15 in x 15 in minimum 8 gauge thick with a wire attached to one corner long enough to reach



Cookie Cutter Sampling Device

from the center of the paver to the outside of the farthest auger extension. Holes ¼" in diameter should be provided in each corner.

- Cookie cutter sampling device: A 13 in. square sampling template, constructed from 3 in. x 2 in. x 1/8 in. formed steel angle with two 4 in. x 6 in. x 3/8 in. handles. See diagram

  Note 1: Sampling Plate and Cookie cutter may be sized appropriately to accommodate sample size requirements.

- Mechanical sampling device

Sample Size

05

Sample size depends on the test methods specified by the agency for acceptance. Check agency requirement for the size required.

Sampling

General

06

1. The material shall be tested to determine variations. The supplier/contractor shall provide equipment for safe and appropriate sampling including sampling devices on plants, when required.
2. Place dense graded mixture samples in cardboard boxes, stainless steel bowls or other agency approved containers. Place open graded mixture samples in stainless steel bowls. Do not put open graded mixture samples in boxes until they have cooled to the point that bituminous material will not migrate from the aggregate.

07

3. Sampling from the Roadway will require the contractor to repair the sampled location.

   Note 2: *Care shall be taken to prevent contamination of bituminous mixes by dust or other foreign matter, and to avoid segregation of aggregate and bituminous materials.*

08

Sampling from a Conveyor Belt

1. Stop the conveyor belt.
2. Select at least three areas locations of approximately equal increments that will form a sample of the required size when combined.
3. Insert belt template in each of the locations to be sampled.
4. Scoop all material inside template into a suitable container.

09

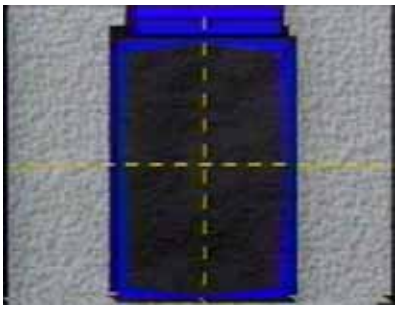
Attached Sampling Devices

Attached Sampling device

10

Some agencies require mechanical sampling devices for hot mix asphalt (HMA) and cold feed aggregate on some projects. These are normally permanently attached devices that allow a sample container to pass perpendicularly through the entire stream of material or divert the entire stream of material into the container. Operation may be hydraulic, pneumatic, or manual and allows the sample container to pass through the stream twice, once in each direction, without overfilling. Special caution is necessary with manually operated systems since a consistent speed is difficult to maintain and non-representative samples may result. Check agency requirements for the specifics of required sampling systems.

1. When using an attached sampling device, pass the container twice through the material perpendicularly without overfilling the container.
2. Repeat until proper sample size has been obtained.



11

12

Quadrants in a load

13

14

15

16

Plate on untreated base

Sampling from Haul Units

1. Visually divide the haul unit into approximately four equal quadrants.
2. In each quadrant, remove and discard approximately 12 in. of material and obtain samples.
3. Combine the increments to form a sample of the required size.

Sampling from Roadway Prior to Compaction (Plate Method)

Plate Method using the "cookie cutter" sampling device.

There are two conditions that will be encountered when sampling Hot Mix Asphalt (HMA) from the roadway prior to compaction. The two conditions are:

1. Laying HMA on grade or untreated base material requires Method 1.
2. Laying HMA on existing asphalt or laying a second lift of HMA requires Method 2.

Cookie cutter and plate can be sized according to test sample needs.

SAFETY:

Sampling is performed behind the paving machine and in front of the breakdown roller. For safety, the roller must remain at least 10 ft behind the sampling operation until the sample has been taken and the hole filled with loose HMA.

Method 1 requires a plate to be placed in the roadway in front of the paving operation. There is always concern when working in the path of moving equipment. It is safest to stop the paving train while a plate is installed in front of the paver. When this is not possible the following safety rules must be followed.

1. The plate placing operation must be at least 10 ft in front of the paver or pickup device. The technician placing the plate must have eye contact and communication with the paving machine operator. If eye contact cannot be maintained at all time, a third person must be present to provide communication between the operator and the technician.
2. No technician is to be between the asphalt supply trucks and the paving machine. The exception to this rule is if the supply truck is moving forward creating a windrow, in which case the technician must be at least 10 ft behind the truck.
3. At any time the Engineer feels that the sampling technique is creating an unsafe condition, the operation is to be halted until it is made safe or the paving operation will be stopped while the plate is being placed.

Method 1 - Obtaining a Sample on Untreated Base:

17

1. Following the safety rules detailed above, the technician is to:
    a. Smooth out a location in front of the paver at least 2 ft inside the edge of the mat.
    b. Lay the plate down diagonally with the direction of travel, keeping it flat and tight to the base with the lead corner facing the paving machine.

18

19

2. Secure the plate in place with a nail through the hole in the lead corner of the plate.
3. Pull the wire, attached to the outside corner of the plate, taut past the edge of the HMA mat and secure with a nail.
4. Let the paving operation proceed over the plate and wire. Immediately proceed with the sampling.
5. Using the exposed end of the wire, pull the wire up through the fresh HMA to locate the corner of the plate. Place the "cookie cutter" sampling device, just inside the end of the wire; align the cutter over the plate. Press "cookie cutter" device down through the HMA to the plate.
6. Using a small square tipped shovel and/or scoop, carefully remove all the HMA from inside of the cutter and place in a sample container.
7. Remove the sample cutter and the plate from the roadway. The hole made from the sampling must be filled with loose HMA.

Method 2 Obtaining a Sample on Asphalt Surface:

1. After the paving machine has passed the sampling point, immediately place the "cookie cutter" sampling device on the location to be sampled. Push the cutter down through the HMA until it is flat against the underlying asphalt mat.
2. Using a small square tipped shovel and/or scoop, carefully remove all the HMA from inside of the cutter and place in a sample container. The hole made from sampling must filled with loose HMA.

20

Identification and Shipping

1. Identify sample containers as required by the agency.
2. Ship samples in containers that will prevent loss, contamination, or damage.

21

Tips!

Check agency requirements for:

- Sample size needed
- Sampling device requirements
- Allowable sampling techniques

22

REVIEW QUESTIONS

1. Bituminous paving mixture sample sizes are based on what?

2. What types of containers are used for asphalt samples?

3. Describe how samples are obtained from:

   - Conveyor belt
   - Plants with attached sampling devices
   - Truck transports
   - Roadway

PERFORMANCE EXAM CHECKLIST (ORAL)

SAMPLING BITUMINOUS PAVING MIXTURES
FOP FOR AASHTO T 168

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. How must a sample be obtained from a conveyor belt?		
a. Stop the belt and insert the template.	_____	_____
b. Remove all material from inside the template.	_____	_____
c. Take three increments.	_____	_____
2. At the hot plant how must a sample be obtained using a sampling device?		
a. Pass the sampling device through stream twice perpendicular to material.	_____	_____
b. The sampling device can not be over filled.	_____	_____
3. What must be done to sample from transport units?		
a. Divide the unit into four quadrants.	_____	_____
b. Obtain increments from each quadrant, 12 in below surface.	_____	_____
4. Describe how to take samples from the roadway using a plate.		
a. Place the plate well in front of the paver.	_____	_____
b. Pull the wire to locate the corner of the plate.	_____	_____
c. Place the cutter on the HMA above the plate and push it down to the plate.	_____	_____
d. Collect all the material inside the cutter.	_____	_____
5. What types of containers can be used?		
a. Card board boxes, stainless steel bowls, or other agency approved containers.	_____	_____
6. What dictates size of sample?		
a. Agency requirements.	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

_____

Examiner Signature _____ WAQTC #:_____

PERFORMANCE EXAM CHECKLIST

SAMPLING BITUMINOUS PAVING MIXTURES FOP FOR AASHTO T 168

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Samples from conveyors taken correctly.		
a. Belt stopped and template inserted?	_____	_____
b. All material removed?	_____	_____
c. Three increments taken?	_____	_____
2. Sample taken with sampling device correctly?	_____	_____
a. Sampling device passed through stream twice perpendicular to material?	_____	_____
b. Sampling device not over filled?	_____	_____
3. Samples from truck transports taken from four quadrants at required depth of 12in?	_____	_____
4. Samples from roadway taken correctly with plate(s).		
a. When on untreated base plate placed well in front of paver?	_____	_____
b. Wire pulled to locate plate corner?	_____	_____
c. Cookie cutter placed on asphalt and pushed through to plate?	_____	_____
d. All material removed from inside the cutter?	_____	_____
5. Sample placed in appropriate container.	_____	_____
6. Sample size meets agency requirements?	_____	_____
7. Sample identified as required?	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

_____

_____

Examiner Signature _____ WAQTC #:_____

REDUCING SAMPLES OF HOT MIX ASPHALT TO TESTING SIZE FOP FOR AASHTO T 328

Significance

02 Samples of bituminous paving mixes taken in accordance with the FOP for AASHTO T 168, or as required by individual approved test methods, are composites and are typically large in size. Materials sampled in the field need to be reduced to appropriate sizes for testing. It is extremely important that the procedure used to reduce the field sample not modify the material properties.

Scope

03 This method covers three procedures for reducing samples of Hot Mixed Asphalt (HMA) to testing size. The reduced portion is to be representative of the original sample.

- Method A – Mechanical Splitter
- Method B – Quartering
- Method C – Riffle Splitter
- A combination of these methods may be used if approved by the agency.

Apparatus

General

04

Oven

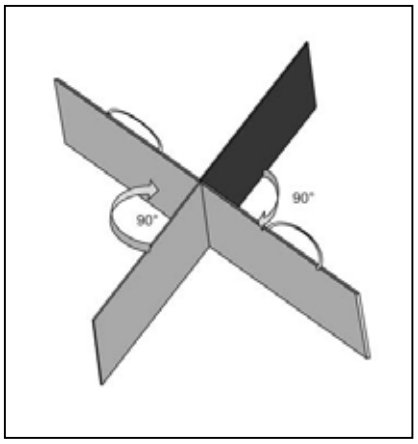
- Thermostatically controlled oven capable of maintaining a temperature of at least 230°F or sufficient to heat the material to a pliable condition for splitting.
- Non-contact temperature measuring device.
- Agency-approved release agent free of solvent or petroleum-based material that could affect asphalt binder.
- Metal spatulas, trowels, straightedges, taping knives, for removing HMA samples from the quartering device, cleaning splitting surfaces, etc.
- Miscellaneous equipment including hot plate, non-asbestos heat-resistant gloves or mittens, pans, buckets, and cans.

Mechanical Splitter

05 • **Mechanical Splitter** having four equal width chutes discharging into four appropriately sized sample receptacles. Splitter to be equipped with

06 a receiving hopper that will hold the sample until the release lever is activated.

- Four sample receptacles of sufficient capacity to accommodate the reduced portion of the HMA sample from the mechanical splitter.
- Refer to AASHTO T 328, Figures 1 through 3, for configuration and required dimensions of the mechanical splitter.



Quartering Template

07 • **Quartering Template** formed in the shape of a cross having equal length sides at right angles to each other. Manufactured of metal that will

08 withstand heat and use without deforming. The sides of the quartering template should be sized such that the length exceeds the diameter of the flattened cone of HMA by an amount allowing complete separation of the quartered sample. (AASHTO T 328 requires length of the sides to be 1.1 times the diameter of the flattened cone of HMA). Height of the sides must exceed the thickness of the flattened cone of HMA.

- Non-stick mixing surface that is hard, heat-resistant, clean, level, and large enough to permit HMA samples to be mixed without contamination or loss of material.

09 • Square-tipped, flat-bottom scoop, shovel or trowel for mixing HMA prior to quartering.

Riffle Splitter

10 • **Riffle Splitter** having a minimum of eight equal width chutes discharging alternately to each side. Minimum chute width must be at least 50% larger than the largest particle size.

11 • Hopper or straight edged pan having width equal or slightly smaller than the assembly of chutes in the riffle splitter to permit uniform discharge of the HMA through the chutes without segregation or loss of material.

• Sample receptacles of sufficient width and capacity to receive the reduced portions of HMA from the riffle splitter without loss of material.

Sampling

12 Obtain samples according to the FOP for AASHTO T 168.

Sample Preparation

13 The sample must be warm enough to separate. If not, warm in an oven until it is sufficiently pliable to mix and separate easily. Do not exceed either the temperature or time limits specified in the test method(s) to be performed.

Selection of Procedure (Method)

14 Select procedure for sample reduction according to agency requirements.

Method A or C is preferred due to the speed with which samples are reduced to testing size. With Method B (Quartering), the repeated mixing and quartering process allows samples to cool rapidly.

The size of the original sample may determine which method is used.

Procedure

Method A – Mechanical Splitter

15

1. After inspecting the apparatus for cleanliness, apply a light coating of approved release agent to all splitter surfaces that will contact HMA.
2. Inspect the hopper gates to be sure they are secured in the closed position.
3. Position the four sample receptacles to receive reduced HMA portions without loss of material.

16

4. Remove the sample from the agency-approved container(s) and place in the mechanical splitter hopper. Avoid segregation, loss of HMA or the accidental addition of foreign material.
5. Release the handle allowing the HMA to drop through the divider chutes and discharge into the four receptacles.

17

6. Inspect splitter surfaces for aggregations of HMA or mastic. If present, clean these surfaces such that the adherent material discharges into the appropriate receptacles.
7. Close and secure the hopper gates.

   Note: *It is possible at this point that material contained in opposite receptacles would equal the required sample size. If this is the case, combine the material from opposite receptacles for the sample.*

Reduced sample

18

8. Further reduce the remaining HMA as needed. Reintroduce material contained in selected receptacles from opposite corners.
9. Repeat the splitting process until an appropriate sample size is obtained for the first test.

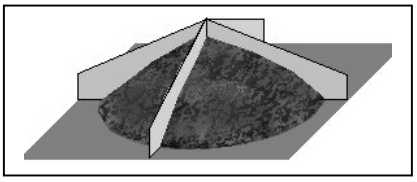
Note 1 - Unless the sample size is grossly in excess of the minimum or exceeds the maximum test size use the sample as reduced for the test.

19

10. Continue the process with the unused portion of the HMA until samples have been obtained for all required tests.
11. Retain and properly identify the remaining unused portion of the HMA sample for further testing if required by the agency.

Method B – Quartering

1. Heat quartering tools to approximately 230ºF (Metal quartering template, scoop or trowel).
2. If needed, apply a light coating of release agent to quartering template.
3. Remove the sample from its container and place in a conical pile on a clean, hard, non-stick surface large enough to permit mixing without contamination or loss of material.
4. Mix thoroughly a minimum of three times using the heated scoop or trowel to turn the sample. Be certain to insert the scoop to the center of the pile to ensure that the entire mass of HMA is being mixed. With the last turning, form again into a conical pile.
5. Flatten the conical pile to a uniform diameter and thickness where the diameter is four to eight times the thickness.
6. Divide the flattened cone into four equal quarters using the quartering template. Press the template through the thickness of the flattened cone assuring complete separation.
7. Leaving the quartering template in place, remove two diagonally opposite quarters and return them to the sample container. Be certain to remove all aggregations of HMA and mastic.
8. Remove the quartering template and combine the remaining quarters, again forming a conical pile.
9. Repeat steps 4 through 8 until a sample of the required size has been obtained. The final sample must consist of the two remaining diagonally opposite quarters.
10. Continue the process with the unused portion of the HMA until samples have been obtained for all required tests.
11. Retain and properly identify the remaining unused portion of the HMA sample for further testing if required by the agency.



Quartering Template (In Place)

Note 1 - Unless the sample size is grossly in excess of the minimum or exceeds the maximum test size use the sample as reduced for the test.

Method C – Riffle Splitter

32 1. Heat splitting tools not to exceed 230ºF. Inspect the riffle splitter for cleanliness and that receptacles are in place to receive the reduced portions of the HMA.

2. Apply a light coating of approved release agent to splitting surfaces (hopper or straight edged pan, chutes, receptacles).

3. Carefully empty the HMA from the sample container into the hopper or straight edged pan without loss of material. Uniformly distribute from side to side of the hopper or pan.

33 4. Discharge the HMA into the splitter at a uniform rate, allowing the HMA to flow freely through the chutes.

5. Inspect splitter surfaces for aggregations of HMA or mastic. If present, clean these surfaces such that the adherent material discharges into the appropriate receptacles.

6. Replace the two receptacles containing the split portions of HMA with two empty ones.

34 7. Using one of the two receptacles containing HMA from the first split, repeat steps 4 and 5 until the HMA contained in one of the two receptacles is the appropriate size for the required test.

8. After each split, remember to inspect splitter hopper and chute surfaces for aggregations of HMA or mastic. If present, clean these surfaces such that the adherent material discharges into the appropriate receptacles.

35 9. Repeat the splitting process with the unused portion of the HMA until samples have been obtained for all required tests.

10. Retain and properly identify the remaining unused portion of the HMA sample for further testing if required by the agency.

Note 1 - Unless the sample size is grossly in excess of the minimum or exceeds the maximum test size use the sample as reduced for the test.

Tips!

- Remember, the reduced sample must be representative of the whole. 36
- Proceed quickly so that splitting is done when the material is hot.
- Check agency requirements about what splitting device(s) or method(s) may be used.
- Method A or C is preferred.
- With Method A, further reduction requires using HMA from diagonally opposite receptacles. 37
- With Methods A or C, inspect splitter surfaces for build-up of HMA aggregations or mastic. Ensure they are cleaned such that the material falls into the appropriate receptacles before continuing with another split.
- With Method B remember that the final sample consists of the two remaining diagonally opposite quarters.

Sample Identification

1. Identify the sample as required by the agency.
2. Samples shall be submitted in agency-approved containers and secured to prevent contamination and loss of material.

REVIEW QUESTIONS

1. What precautions must be taken with the tools used in splitting?

2. What type(s) of equipment can be used for HMA sample reduction?

3. Describe how the “Mechanical Splitter” is prepared for use.

4. Describe the requirements for the Quartering Template.

5. How are methods A, B, & C different?

6. Can methods A, B, and C be used in combination?

7. Describe the Riffle Splitter (configuration, chute size, number of chutes, etc.)

8. Which sample reduction method(s) is preferred? Why?

9. Describe the final sample as reduced by the Quartering method.

10. Describe what the approved release agent cannot contain.

PERFORMANCE EXAM CHECKLIST

REDUCING SAMPLES OF HOT MIX ASPHALT TO TESTING SIZE FOP FOR AASHTO T 328

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Sample obtained by FOP for AASHTO T 168?	_____	_____
2. Sample warmed if not sufficiently pliable to separate easily?	_____	_____
3. Tools such as trowels, spatulas, taping knives, etc. heated?	_____	_____
Method A (Mechanical Splitter)		
4. Splitter checked for cleanliness and receptacles in place?	_____	_____
5. Splitter surfaces that will contact HMA coated with approved release agent?	_____	_____
6. Sample introduced into hopper without segregation or loss of material?	_____	_____
7. Hopper opened. HMA readily and uniformly flows into receptacles?	_____	_____
8. Splitter surfaces inspected, cleaned if needed. Aggregations of mastic or HMA scraped so they fall into appropriate receptacles?	_____	_____
9. Receptacles from opposite corners combined and steps 6 through 8 repeated until sample of required size obtained?	_____	_____
10. Unused portions of HMA then used for continuing the splitting process until samples for all required tests are obtained?	_____	_____
11. Remaining HMA stored in suitable container, properly labeled?	_____	_____
Method B (Quartering)		
12. Tools preheated to approximately 230ºF?	_____	_____
13. Sample placed on hard, non-stick, heat-resistant splitting surface?	_____	_____
14. Sample mixed by turning over a minimum 3 times?	_____	_____
15. Conical pile formed and then flattened?	_____	_____
16. Diameter equal to about 4 to 8 times thickness?	_____	_____
17. Divided into 4 equal portions with heated metal quartering template?	_____	_____
18. Leaving template in place, two diagonally opposite quarters removed and returned to sample container?	_____	_____

OVER

19. Cleared spaces scraped clean? _____ _____
20. Remaining two quarters combined and steps 14 through 19 repeated until sample of required size is obtained? _____ _____
21. Final sample size consists of two diagonally opposite quarters? _____ _____
22. Process continued with unused portions of HMA until samples for all required tests obtained? _____ _____
23. Remaining unused HMA stored in suitable container, properly labeled? _____ _____

Method C (Riffle Splitter)

24. Splitting apparatus and tools preheated to approximately 230ºF? _____ _____
25. Splitter and pans inspected for cleanliness and approved release agent applied? _____ _____
26. Material removed from sample container and placed in hopper or straight edged pan uniformly distributed from side to side? _____ _____
27. Material discharged across chute assembly at controlled rate allowing free flow of HMA through chutes into receptacles? _____ _____
28. Chutes and hopper inspected for cleanliness. Aggregations of HMA or mastic scraped so they fall into appropriate receptacles? _____ _____
29. Receptacles removed and replaced with clean, empty ones? _____ _____
30. Using one receptacle containing HMA from the first split, steps 27 through 28 repeated until sample of the required size is obtained? _____ _____
31. Process continued with unused portions of HMA until samples for all required tests obtained? _____ _____
32. Remaining unused HMA stored in suitable container, properly labeled? _____ _____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

Examiner Signature _____ WAQTC #:_____

MOISTURE CONTENT OF HOT MIX ASPHALT (HMA) BY OVEN METHOD FOP FOR AASHTO T 329

Significance

01 Even though aggregate used in HMA is heated and dried at high temperatures, some types of rock retain moisture. The moisture content of the mix must be known in order to correctly determine the asphalt binder content of the mix. Moisture (water) in the mix will yield erroneously high asphalt binder content values whether asphalt binder content is determined by the nuclear content gauge or ignition furnace method.

02

Scope

This procedure covers the determination of moisture content of HMA in accordance with AASHTO T 329.

Summary

03 A test sample of HMA is dried in an oven. The moisture content is calculated by one of two methods depending upon agency standards.

- When asphalt binder content is reported as a percent of the initial mass of HMA, moisture content is calculated and reported as a percent of the initial, moist mass of mix.
- When asphalt binder content is reported as a percent of the mass of aggregate, moisture content is calculated and reported as a percent of the final, dry mass of mix.

Apparatus

Oven

04

- Balance or scale: 2 kg capacity, readable to 0.1 g conforming to AASHTO M 231
- Forced Draft, Ventilated, or Convection Oven: Capable of maintaining the temperature surrounding the sample at 325 ±25°F

05

- Sample Container: Clean, dry, not affected by heat and of sufficient size to contain a test sample without danger of spilling
- Thermometer or other suitable device with a temperature range of 50-500°F

Quartering

Sample

The test sample shall be obtained in accordance with AASHTO T 168, and reduced in accordance with AASHTO T 328. The size of the test sample shall be a minimum of 1000 g.

Procedure

1. Preheat the oven to a minimum of 221°F but do not exceed the Job Mix Formula (JMF) mixing temperature.

Note 1: For repeatability between laboratories the preferred practice is to dry the sample at no less than 15 °F below the JMF mixing temperature

Mass of sample container

2. Determine and record the mass of the sample container including release media to the nearest 0.1 g.
3. Place the test sample in the sample container.
4. Determine and record the temperature of the test sample.
5. Determine and record the total mass of the sample container and test sample to the nearest 0.1 g.
6. Calculate the initial, moist mass (M_i) of the test sample by subtracting the mass of the sample container determined in Step 2 from total mass of the sample container and the test sample determined in Step 5.
7. The test sample shall be initially dried for 90 + 5 minutes, and its mass determined. Then, at 30 + 5 min intervals until constant mass is achieved.

Note 1: Constant mass shall be defined as the mass at which further drying does not alter the mass by more than 0.05 percent

Mass determination

8. Cool the sample container and test sample to ±15°F of the temperature determined in Step 4.
9. Determine and record the total mass of the sample container and test sample to the nearest 0.1 g.

Note 2: Do not attempt to remove the test sample from the sample container for the purposes of determining mass.

10. Calculate the final, dry mass (M_f) of the test sample by subtracting the mass of the sample container determined in Step 2 from the total mass of the sample container and the test sample determined in Step 9.

Note 3: Moisture content and the number of samples in the oven will affect the rate of drying at any given time. Placing wet samples in the oven with nearly dry samples could affect the drying process.

Calculations

Constant Mass:

Calculate constant mass using the following formula: 13

$$\frac{M_p - M_n}{M_p} \times 100 = \%Change$$

Where: M_p = previous mass measurement

M_n = new mass measurement

Example:

Mass of container: 232.6 g 14

Mass of container after first drying cycle: 1361.8 g

Mass, M_p, of possibly dry sample: 1361.8 g – 232.6 g = 1129.2 g

Mass of container and dry sample after second drying cycle: 1360.4 g

Mass, M_n, of dry sample: 1360.4 g – 232.6 g = 1127.8 g

$$\frac{1129.2 - 1127.8}{1129.2} \times 100 = 0.12\%$$

0.12% is greater than 0.05% so continue drying

Mass of container and dry sample after third drying cycle: 1359.9 g

Mass, M_n, of dry sample: 1359.9g – 232.6g = 1127.3g 15

$$\frac{1127.8 - 1127.3}{1127.8} \times 100 = 0.04\%$$

0.04% is not greater than 0.05% constant mass has been reached

Moisture Content:

Calculate the moisture content, as a percent, using one of the following two formulas.

Percent of Initial, Moist Mass:

$$\frac{M_i - M_f}{M_i} \times 100 = \text{Moisture Content} \quad (16)$$

Where: M_i = initial, moist mass

M_f = final, dry mass

Example:

M_i = 1134.9 g

M_f = 1127.3 g

$$\text{Moisture Content} = \frac{1134.9\,\text{g} - 1127.3\,\text{g}}{1134.9\,\text{g}} \times 100 = 0.670, \textit{ say } 0.67\%$$

Percent of Final, Dry Mass:

$$\frac{M_i - M_f}{M_f} \times 100 = \text{Moisture Content} \quad (17)$$

Where: M_i = initial, moist mass

M_f = final, dry mass

Example:

M_i = 1134.9 g

M_f = 1127.3 g

$$\text{Moisture Content} = \frac{1134.9\,\text{g} - 1127.3\,\text{g}}{1127.3\,\text{g}} \times 100 = 0.674, \textit{ say } 0.67\%$$

Report

18 Results shall be reported on standard forms approved for use by the agency. Report the moisture content to 0.01 percent.

Tips!

19
- Remember: Moisture content is expressed as a percent of initial, moist mass when binder content is reported as a percent of mix mass.
- Remember: Moisture content is expressed as a percent of final, dry mass when asphalt binder content is reported as a percent of aggregate mass.

REVIEW QUESTIONS

1. What is the minimum sample size needed?

2. The sample shall be initially dried for _____ minutes.

3. Further drying shall be in _____ minute intervals.

4. How is constant mass defined for this procedure?

PERFORMANCE EXAM CHECKLIST

MOISTURE CONTENT OF HOT MIX ASPHALT BY OVEN METHOD FOP FOR AASHTO T 329

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Mass of clean dry container including release media determined to 0.1 g?	_____	_____
2. Representative sample obtained; 1000 g minimum?	_____	_____
3. Initial temperature taken and recorded?	_____	_____
4. Mass of sample determined to 0.1 g?	_____	_____
5. Sample placed in drying oven for 90 minutes?	_____	_____
6. Sample dried not exceeding the JMF mixing temp?	_____	_____
7. Constant mass checked?	_____	_____
8. Sample and container cooled to ±15°F of the initial temperature before final mass determined to 0.1 g?	_____	_____
9. Calculation of moisture content performed correctly to 0.01%?	_____	_____

% Moisture as percent of Dry Mass

$$\frac{M_i - M_f}{M_f} \times 100$$

% Moisture as percent of Wet Mass

$$\frac{M_i - M_f}{M_i} \times 100$$

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

Examiner Signature _____WAQTC #:_____

DETERMINING THE ASPHALT BINDER CONTENT OF HOT MIX ASPHALT (HMA) BY THE IGNITION METHOD FOP FOR AASHTO T 308

01

02

Ignition oven

03

Significance

The quality of hot mix asphalt (HMA) is greatly dependent on having the correct content of asphalt binder. HMA placed on the job must be tested to ensure that the binder content is within the specified range.

Scope

This procedure covers the determination of asphalt binder content of hot mix asphalt (HMA) by ignition of the binder at 1000°F (538°C) or less in a furnace; samples may be heated by convection or direct infrared irradiation. The aggregate remaining after burning can be used for sieve analysis using the FOP for AASHTO T 30.

Two methods – A and B – are presented.

Some agencies allow the use of recycled HMA. When using recycled HMA, check with the agency for specific correction procedures.

04

Background on Test Method

Asphalt binder in the HMA is ignited in a furnace. Asphalt binder content is calculated as the difference between the initial mass of the HMA and the mass of the residual aggregate, correction factor, and moisture content. The asphalt binder content is expressed as percent of moisture-free mix mass.

Sampling

1. Obtain samples of HMA in accordance with the FOP for AASHTO T 168.

05

2. Reduce HMA samples in accordance with the FOP for AASHTO T 328.
3. If the mixture is not sufficiently soft to separate with a spatula or trowel, place it in a large flat pan in an oven at 257 ±9°F until soft enough.

4. Test sample size shall conform to the mass requirement shown in Table 1.

Note 1: When the mass of the test specimen exceeds the capacity of the equipment used, the test specimen may be divided into suitable increments, tested, and the results appropriately combined through a weighted average for calculation of the asphalt binder content.

06

Table 1

Nominal Maximum Size* (in.)	Minimum Mass Specimen g	Maximum Mass Specimen g
1½	4000	4500
1	3000	3500
3/4	2000	2500
1/2	1500	2000
3/8	1200	1700
No. 4	1200	1700

07

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

Ignition furnace

09

Apparatus

Note 2: The apparatus must be calibrated for the specific mix design. See "Correction factor" at the end of this FOP.

08

There are two methods – A and B. The apparatus for the two methods are the same except that the furnace for Method A has an internal balance.

- Forced air ignition furnace, capable of maintaining the temperature at 1072°F (578°C).

  For Method A, the furnace will be equipped with an internal scale thermally isolated from the furnace chamber and accurate to 0.1 g. The scale shall be capable of determining the mass of a 3500 g sample in addition to the sample baskets. A data collection system will be

included so that mass can be automatically determined and displayed during the test. The furnace shall have a built-in computer program to calculate change in mass of the sample baskets and provide for the input of a correction factor for aggregate loss. The furnace shall provide a printed ticket with the initial specimen mass, specimen mass loss, temperature compensation, correction factor, corrected asphalt binder content, test time, and test temperature. The furnace shall provide an audible alarm and indicator light when the sample mass loss does not exceed 0.01% of the total sample mass for three consecutive minutes.

10

11

Note 3: The furnace shall be designed to permit the operator to change the ending mass loss percentage from 0.01% to 0.02%.

Sample (maximum 3500 g)

For both Method A and Method B, the furnace chamber dimensions shall be adequate to accommodate a 3500 g sample. The furnace door shall be equipped so that it cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided and the furnace shall be vented so that no emissions escape into the laboratory. The furnace shall have a fan to pull air through the furnace to expedite the test and to eliminate the escape of smoke into the laboratory.

- Sample Basket Assembly: consisting of sample basket(s), catch pan, and basket guards. Sample basket(s) will be of appropriate size allowing samples to be thinly spread and allowing air to flow through and around the sample particles. Sets of two or more baskets shall be nested. A catch pan: of sufficient size to hold the sample basket(s) so that aggregate particles and melting asphalt binder falling through the screen mesh are caught. Basket guards will completely enclose the basket and be made of screen mesh, perforated stainless steel plate, or other suitable material.

Note 4: Screen mesh or other suitable material with maximum and minimum opening of No. 8 and No. 30 respectively has been found to perform well.

- Thermometer, or other temperature measuring device, with a temperature range of 50 -500°F
- Oven capable of maintaining 257 ±9°F.
- Balance or scale: capacity sufficient for the sample mass and conforming to the requirements of M 231, Class G2.
- **Safety equipment**: Safety glasses or face shield, high temperature gloves, long sleeve jacket, a heat resistant surface capable of withstanding 1202°F (650°C), and a protective cage capable of surrounding the sample baskets during the cooling period. Particle mask for use during removal of the sample from the basket assembly.
- Miscellaneous equipment: A pan larger than the sample basket(s) for transferring sample after ignition, spatulas, bowls, and wire brushes.

Two nested baskets and catch pan

Procedure – Method A (Internal Balance)

1. Preheat the ignition furnace to 1000°F (538°C) or to the temperature determined in the "Correction Factor" section, Step 9 of this method. Manually record the furnace temperature (set point) prior to the initiation of the test if the furnace does not record automatically.

   Dry the sample to constant mass according to the FOP for AASHTO T 329; or determine the moisture content of a companion sample in accordance with the FOP for AASHTO T 329.

2. Determine and record the mass to the nearest 0.1 g of the sample basket assembly.

3. Evenly distribute the sample in the sample basket assembly, taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the sample.

4. Determine and record the total mass to the nearest 0.1 g, of the sample and sample basket assembly. Calculate and record the initial mass of the sample (total mass minus the mass of the sample basket assembly) to the nearest 0.1 g. Designate this mass as (M_i).

15

16

Placing sample in oven

5. Record the asphalt binder correction factor or input into the furnace controller for the specific HMA.
6. Input the initial mass (M_i) of the sample into the ignition furnace controller. Verify that the correct mass has been entered.
7. "Zero" the balance.

CAUTION: Operator should wear safety equipment – high temperature gloves, face shield, fire-retardant shop coat – when opening the door to load or unload the sample.

8. Open the chamber door and gently set the sample basket assembly in the furnace. Carefully position the sample basket assembly so it is not in contact with the furnace wall. Close the chamber door and verify that the sample mass displayed on the furnace scale equals the total mass of the sample and sample basket assembly recorded in Step 5 within ±5 g.

Note 5: Furnace temperature will drop below the set point when the door is opened, but will recover when the door is closed and ignition begins. Sample ignition typically increases the temperature well above the set point – relative to sample size and asphalt binder content.

9. Initiate the test by pressing the start button. This will lock the sample chamber and start the combustion blower.

17

Safety note: Do not attempt to open the furnace door until the asphalt binder has been completely burned off.

10. Allow the test to continue until the stable light and audible stable indicator indicate that the change in mass does not exceed 0.01% for three consecutive minutes. Press the stop button. This will unlock the sample chamber and cause the printer to print out the test results.

Note 6: An ending mass loss percentage of 0.02 may be used, if allowed by the agency, when aggregate that exhibits an excessive amount of loss during ignition testing is used.

18

11. Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample basket assembly and allow it to cool to room temperature (approximately 30 minutes).

Sample basket(s) and protective cage

12. Determine and record the total after ignition mass to the nearest 0.1 g. Calculate and record the mass of the sample, after ignition (total after ignition mass minus the mass of the sample basket assembly) to the nearest 0.1 g. Designate this mass as M_f.

19

13. Use the asphalt binder content percentage from the printed ticket. If the sample was not oven dried and a moisture content percentage has been determined, subtract the moisture content from the printed ticket asphalt binder content and report the difference as the corrected asphalt binder content.

$$P_b = BC - M - C_f$$ (if not input in the furnace controller)

20

where:

P_b = the corrected asphalt binder content as a percent by mass of the HMA

BC = Asphalt binder content shown on printed ticket

M = percent moisture as determined by the FOP for AASHTO T 329.

C_f = Asphalt binder correction factor as a percent by mass of the HMA sample

Asphalt binder content percentage can also be calculated using the formula from step 16 of Method B.

Procedure – Method B (External Balance)

1. Preheat the ignition furnace to 1000°F (538°C) or to the temperature determined in the "Correction Factor" section Step 9. Manually record the furnace temperature (set point) prior to the initiation of the test if the furnace does not record automatically.
2. Dry the sample to constant mass according to the FOP for AASHTO T 329 or determine the moisture content of a companion sample in accordance with the FOP for AASHTO T 329.
3. Determine and record the mass to the nearest 0.1 g of the sample basket assembly.
4. Place the sample basket(s) in the catch pan. Evenly distribute the sample in the sample basket(s), taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the sample.
5. Determine and record the total mass to the nearest 0.1 g of the sample and sample basket assembly. Calculate and record the initial mass of the sample (total mass minus the mass of the sample basket assembly) to the nearest 0.1 g. Designate this mass as (M_i).
6. Record the asphalt binder correction factor for the specific HMA.
7. Open the chamber door and gently set the sample basket assembly in the furnace. Carefully position the sample basket assembly so it is not in contact with the furnace wall. Burn the HMA sample in the furnace for 45 minutes or the length of time determined in "Correction Factor" section.

8. Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample and allow it to cool to room temperature (approximately 30 min).
9. Determine and record the total after ignition mass to the nearest 0.1 g. Calculate and record the mass of the sample, after ignition, (total after ignition mass minus the mass of the sample basket assembly) to the nearest 0.1 g.
10. Place the sample basket assembly back into the furnace.
11. Burn the sample for at least 15 minutes after the furnace reaches the set temperature.
12. Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample basket assembly and allow it to cool to room temperature (approximately 30 min).
13. Determine and record the total after ignition mass to the nearest 0.1 g. Calculate and record the mass of the sample, after ignition, (total after ignition mass minus the mass of the sample basket assembly) to the nearest 0.1 g.
14. Repeat Steps 10 through 13 until the change in measured mass, of the sample after ignition, does not exceed 0.01 percent of the previous sample mass, after ignition.

Note 7: An ending mass loss percentage of 0.02 may be used, if allowed by the agency, when aggregate that exhibits an excessive amount of loss during ignition testing is used.

15. Record the final value obtained as M_f, the final mass of the sample after ignition.

16. Calculate the asphalt binder content of the sample as follows:

$$P_b = \left[\frac{M_i - M_f}{M_i}\right] \times 100 - C_f - M$$

27

where:

P_b = the corrected asphalt binder content as a percent by mass of the HMA sample

M_f = the final mass of aggregate remaining after ignition

M_i = the initial mass of the HMA sample prior to ignition

C_f = Asphalt binder correction factor as a percent by mass of the HMA sample

M = percent moisture as determined by the FOP for AASHTO T 329

Example

Initial Mass of Sample and Basket = 5292.7

Mass of Basket Assembly = 2931.5

28

M_i = 2361.2

Mass after First ignition + basket = 5154.4

Sample Mass after First ignition = 2222.9

Sample Mass after additional

15 min ignition = 2222.7

$$\frac{(2222.9 - 2222.7)}{2222.9} \times 100 = 0.009$$

Not greater than 0.01%, so

M_f = 2222.7

29

$$\frac{(2361.2 - 2222.7)}{2361.2} \times 100 - 0.42 - 0.04 = 5.41\%$$

P_b= 5.41%

Gradation

1. Empty contents of the basket(s) into a flat pan, being careful to capture all material. Use a small wire brush to ensure all residual fines are removed from the baskets.

Note 8: Particle masks are a recommended safety precaution.

2. Perform the gradation analysis in accordance with the FOP for AASHTO T 30.

Report

Results shall be reported on standard forms approved by the agency. Include:

- Method of test (A or B)
- Corrected asphalt binder content, P_b Per Agency Standard
- Correction factor, C_f to 0.01%
- Temperature compensation factor (if applicable)
- Total percent loss
- Sample mass
- Moisture content to 0.01%
- Test temperature.

Attach the original printed ticket with all intermediate values (continuous tape) to the report for furnaces with internal balances.

33

Correction Factors

Asphalt Binder and Aggregate

Asphalt binder content results may be affected by the type of aggregate in the mixture and by the ignition furnace. Asphalt binder and aggregate correction factors must, therefore, be established by testing a set of correction specimens for each Job Mix Formula (JMF) mix design. Each ignition furnace will have its own unique correction factor determined in the location where testing will be performed.

34

This procedure must be performed before any acceptance testing is completed, and repeated each time there is a change in the mix ingredients or design. Any changes greater than 5% in stockpiled aggregate proportions should require a new correction factor.

All correction samples will be prepared by a central / regional laboratory unless otherwise directed.

Asphalt binder correction factor: A correction factor must be established by testing a set of correction specimens for each Job Mix Formula (JMF). Certain aggregate types may result in

35

unusually high correction factors (> 1.0%). Such mixes should be corrected and tested at a lower temperature as described below.

Aggregate correction factor: Due to potential aggregate breakdown during the ignition process, a correction factor will need to be determined for the following conditions:

a) Aggregates that have a proven history of excessive breakdown

b) Aggregate from an unknown source.

36

This correction factor will be used to adjust the acceptance gradation test results obtained according to the FOP for AASHTO T 30.

Procedure

1. Obtain samples of aggregate in accordance with the FOP for AASHTO T 2.
2. Obtain samples of asphalt binder in accordance with the FOP for AASHTO T 40.

Note 9: Include other additives that may be required by the JMF.

3. Prepare an initial, or "butter," mix at the design asphalt binder content. Mix and discard the butter mix prior to mixing any of the correction specimens to ensure accurate asphalt content.
4. Prepare two correction specimens at the JMF design asphalt binder content. Aggregate used for correction specimens shall be sampled from material designated for use on the project. An agency-approved method will be used to combine aggregate. An additional "blank" specimen shall be batched and tested for aggregate gradation in accordance with the FOP for AASHTO T 30. The gradation from the "blank" shall fall within the agency specified mix design tolerances.
5. Place the freshly mixed specimens directly into the sample basket assembly. If mixed specimens are allowed to cool prior to placement in the sample basket assembly, the specimens must be dried to constant mass according to the FOP for AASHTO T 329. Do not preheat the sample basket assembly.
6. Test the specimens in accordance with Method A or Method B of the procedure.
7. Once both of the correction specimens have been burned, determine the asphalt binder content for each specimen by calculation or from the printed oven tickets, if available.

8. If the difference between the asphalt binder contents of the two specimens exceeds 0.15%, repeat with two more specimens and, from the four results, discard the high and low result. Determine the correction factor from the two original or remaining results, as appropriate. Calculate the difference between the actual and measured asphalt binder contents for each specimen. The asphalt binder correction factor, C_f, is the average of the differences expressed as a percent by mass of HMA.

9. If the asphalt binder correction factor exceeds 1.0%, the test temperature must be lowered to 900 ±8°F (482 ±5°C) and new samples must be burned.

Note 10: The temperature for determining the asphalt binder content of HMA samples by this procedure shall be the same temperature determined for the correction samples.

10. Perform a gradation analysis on the residual aggregate in accordance with the FOP for AASHTO T 30, if required. The results will be utilized in developing an "Aggregate Correction Factor" and should be calculated and reported to 0.1%.

11. Subtract the % passing for each sieve, for each sample, from the % passing each sieve of the "Blank" specimen gradation results in Step 4.

12. Determine the average difference of the two values. If the difference for any single sieve exceeds the allowable difference of that sieve as listed in Table 2, then aggregate gradation correction factors (equal to the resultant average differences) for all sieves shall be applied to all acceptance gradation test results determined by the FOP for AASHTO T 30. If the No. 200 is the only sieve outside the limits in Table 2, apply the aggregate correction factor to only the No. 200 sieve.

47

Table 2
Permitted Sieving Difference

Sieve	Allowable Difference
Sizes larger than or equal to No.8	± 5.0%
Sizes larger than No.200 and smaller than No.8	± 3.0%
Sizes No.200 and smaller	± 0.5%

48

Examples:

Sieve Size (in.)	Correction Factor Blank Sample, % Passing	Correction Factor Sample #1, % Passing	Correction Factor Sample #2, % Passing	Difference 1 / 2	Avg. Diff.	Sieves to adjust
3/4	100	100	100	0/0	0.0	
1/2	86.3	87.4	86.4	-1.1/-0.1	-0.6	
3/8	77.4	76.5	78.8	+0.9/-1.4	-0.2	
No. 4	51.5	53.6	55.9	-2.1/-4.4	-3.2	
No. 8	34.7	36.1	37.2	-1.4/-2.5	-2.0	
No. 16	23.3	25.0	23.9	-1.7/-0.6	-1.2	
No. 30	16.4	19.2	18.1	-2.8/-1.7	-2.2	
No. 50	12.0	11.1	12.7	+0.9/-0.7	+0.1	
No. 100	8.1	9.9	6.3	-1.8/+1.8	0.0	
No. 200	5.5	5.9	6.2	-0.4/-0.7	-0.6	- 0.6

49

In this example all acceptance gradation test results (FOP for AASHTO T 30) performed on the residual aggregate would have an “Aggregate Correction Factor”. This factor would be -0.6% on the No. 200 sieve and would be applied to the % passing No. 200 sieve.

50

Sieve Size (in.)	Correction Factor Blank Sample, % Passing	Correction Factor Sample #1, % Passing	Correction Factor Sample #2, % Passing	Difference 1 / 2	Avg. Diff.	Sieves to adjust
3/4	100	100	100	0/0	0.0	0.0
1/2	86.3	87.4	86.4	-1.1/-0.1	-0.6	-0.6
3/8	77.4	76.5	78.8	+0.9/-1.4	-0.2	-0.2
No. 4	51.5	55.6	57.9	-4.1/-6.4	-5.2	**-5.2**
No. 8	34.7	36.1	37.2	-1.4/-2.5	-2.0	-2.0
No. 16	23.3	25.0	23.9	-1.7/-0.6	-1.2	-1.2
No. 30	16.4	19.2	18.1	-2.8/-1.7	-2.2	-2.2
No. 50	12.0	11.1	12.7	+0.9/-0.7	+0.1	+0.1
No. 100	8.1	9.9	6.3	-1.8/+1.8	0.0	0.0
No. 200	5.5	5.9	6.2	-0.4/-0.7	-0.6	-0.6

51

In this example all acceptance gradation test results (FOP for AASHTO T 30) performed on the residual aggregate would have an “Aggregate Correction Factor”. The correction factor for each sieve must be applied because the average difference on the No. 4 is outside the tolerance from Table 2.

52

Tips!

- Check specific agency requirements
- Make sure apparatus is calibrated to specific mix design
- Do not open door until asphalt binder has burned off

REVIEW QUESTIONS

1. Summarize the sampling procedures used for the various materials tested.

2. Upon what is the size of the test sample based?

3. Describe when and how the two Correction Factor's are used.

4. Describe the difference in the apparatus for the two methods – A and B.

5. Describe one of the two methods – A or B.

6. What is done with the material removed from the ignition oven?

PERFORMANCE EXAM CHECKLIST

DETERMINING THE ASPHALT BINDER CONTENT OF HOT MIX ASPHALT (HMA) BY THE IGNITION METHOD FOP FOR AASHTO T 308

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	Trial 1	Trial 2
1. Oven at correct temperature 1000°F (538°C) or correction Factor temperature?	_____	_____
2. Sample reduced to correct size?	_____	_____
3. HMA sample or companion moisture sample taken and dried per FOP for AASHTO T 329?	_____	_____
4. Mass of sample basket assembly recorded to 0.1 g?	_____	_____
5. With pan below basket(s) sample evenly distributed in basket(s)?	_____	_____
6. Sample conforms to the required mass and mass recorded to 0.1 g?	_____	_____
7. Method A		
a. Initial mass entered into furnace controller?	_____	_____
b. Balance "zeroed."	_____	_____
c. Sample correctly placed into furnace?	_____	_____
d. Test continued until stable indicator signals?	_____	_____
e. Uncorrected binder content obtained on printed ticket?	_____	_____
f. Sample mass determined to nearest 0.1 g.?	_____	_____
8. Method B		
a. Sample correctly placed into furnace?	_____	_____
b. Sample burned for 45 min or time determined by correction process?	_____	_____
c. Sample cooled to room temperature?	_____	_____
d. Sample burned to constant mass?	_____	_____
e. Sample mass determined to nearest 0.1 g.?	_____	_____
f. Uncorrected binder content calculated correctly and recorded?	_____	_____

OVER

Procedure Element	**Trial 1**	**Trial 2**
9. Binder content corrected for Correction Factor if needed?	_____	_____
10. Binder content corrected for moisture per T 329 if needed?	_____	_____
11. Corrected binder content recorded?	_____	_____
12. Contents of the basket(s) carefully empted into a pan?	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

_____

_____

Examiner Signature _____WAQTC #:_____

THEORETICAL MAXIMUM SPECIFIC GRAVITY AND DENSITY OF HOT MIX ASPHALT PAVING MIXTURES
FOP FOR AASHTO T 209

Significance

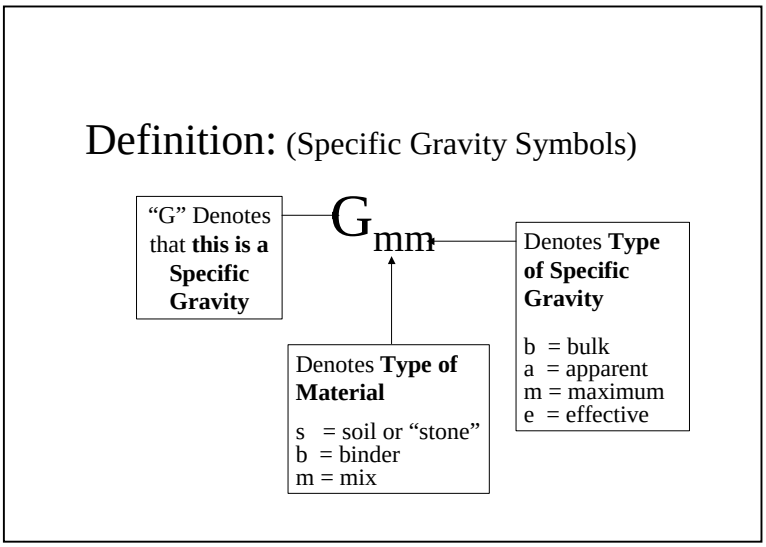
01 Maximum specific gravity (G_{mm}) is the ratio of the mass of a given volume of cooled hot mix asphalt (HMA) at 77°F to the mass of an equal volume of water at the same temperature. The procedure is often called the Rice test after its developer, James Rice. G_{mm} is used in conjunction with bulk specific gravity to determine in-place density and / or percent

02 air voids in compacted HMA. Percentage of air voids, V_a, is significant because durability characteristics of HMA are influenced by the amount of voids in the compacted material.

Scope

03 This procedure covers the determination of the maximum specific gravity (G_{mm}) of un-compacted Hot Mix Asphalt (HMA) paving mixtures in accordance with AASHTO T 209. Two methods using two different containers – bowl and flask – are covered.

04 Specimens prepared in the laboratory shall be cured according to the agency standard.



Metal container/ Volumetric Flask

05

Apparatus

- Balance or scale: 10,000 g capacity, readable to 0.1 g
- Container: A glass, metal, or plastic bowl or volumetric flask capable of holding a 2000 g sample and withstanding a partial vacuum
- Container cover: A glass plate or a metal or plastic cover with a vented opening.

06

- Vacuum Lid: A transparent lid with a suitable vacuum connection. The vacuum opening to be covered with a fine wire mesh
- Vacuum pump or water aspirator: Capable of evacuating air from the container to a residual pressure of 30 mm Hg (4.0 kPa).
- Residual Pressure Manometer or Vacuum gauge: Traceable to NIST and capable of measuring residual pressure down to 30 mm Hg (4.0 kPa) or less
- Manometer or Vacuum gauge: Capable of measuring the vacuum being applied at the source of the vacuum
- Water bath: A constant-temperature water bath (optional)
- Thermometers: Calibrated liquid-in-glass, or electronic digital total immersion type, accurate to 0.9°F
- Bleeder valve to adjust vacuum.
- Timer

07

Calibration of Flask

Use a volumetric flask that is calibrated to accurately determine the mass of the flask filled with water, at 77 ±0.9°F. The volumetric flask shall be calibrated periodically in conformance with procedures established by the agency.

08

Test Sample Preparation

1. Obtain samples in accordance with the FOP for AASHTO T 168 and reduce according to AASHTO T 328.
2. Test sample size shall conform to the requirements of Table 1. Samples larger than the

capacity of the container may be tested in two or more increments. Results will be combined and averaged. If the increments have a specific gravity difference greater than 0.018 for the bowl method and 0.011 for the flask method the test must be re-run.

Table 1
Test Sample Size for G_{mm}

Size of Largest Particle of Aggregate in Mixture (in.)	Minimum Mass g
2	6000
1½	4000
1	2500
3/4	2000
1/2	1500
3/8	1000
No. 4	500

09

10

Separating particles

Procedure – General

11 Two procedures – bowl and flask – are covered. The first 11 steps are the same for both.

1. Separate the particles of the sample, taking care not to fracture the mineral particles, so that the particles of the fine aggregate portion are not larger than 1/4 in. If the mixture is not sufficiently soft to be separated manually, place it in a large flat pan and warm in an oven only until it is pliable enough for separation.
2. Cool the sample to room temperature.

12 3. Determine and record the mass of the dry bowl or flask, including the cover, to the nearest 0.1 g.

13 4. Place the sample in the bowl or flask.

5. Determine and record the mass of the dry bowl or flask, cover, and sample to the nearest 0.1 g.
6. Determine and record the mass of the sample by

Placing sample in flask

subtracting the mass determined in Step 3 from the mass determined in Step 5. Designate this mass as "A".

7. Add sufficient water at approximately 77°±1.8°F to cover the sample by about 1 in.

Note 1: The release of entrapped air may be facilitated by the addition of a wetting agent. Check with the agency to see if this is permitted and, if it is, for a recommended agent.

8. Place the lid on the bowl or flask and attach the vacuum line. To ensure a proper seal between the flask and the lid, wet the O-ring or use a petroleum gel.

9. Remove entrapped air by subjecting the contents to a partial vacuum of 27.5 ±2.5 mm Hg (3.7 ±0.3 kPa) residual pressure for 15 ±2 minutes.

10. Agitate the container and contents, either continuously by mechanical device or manually by vigorous shaking, at 2-minute intervals. This agitation facilitates the removal of air.

11. Turn off the vacuum pump, slowly open the release valve, and remove the lid.

Procedure – Bowl

12A. Suspend and immerse the bowl and contents in water at 77 ±1.8°F for 10 ±1 minutes. The holder shall be immersed sufficiently to cover it and the bowl.

13A. Determine and record the submerged weight of the bowl and contents to the nearest 0.1 g.

14A. Empty and re-submerge the bowl following step 12A to determine the submerged weight of the bowl to the nearest 0.1 g.

15A. Determine and record the submerged weight of the sample the nearest 0.1 g by subtracting the

submerged weight of the bowl from the submerged weight determined in Step 13A. Designate this submerged weight as "C".

Procedure – Flask

22

Note 2: Stabilize the temperature of the flask and contents to 77 ±1.8°F and determine final mass of the flask, cover, de-aired water, and sample within 10 ±1 minutes of completing Step 11.

23

Determining mass

12B. Fill the flask with water and adjust the temperature to 77 ±1.8°F.

13B. Stabilize the temperature of the flask and contents in a water bath so that final temperature is within 77 ±1.8°F.

24

Note 3: In lieu of placing the flask in the water bath, determine the temperature of the water in the flask and make the appropriate density correction using Table 2 when the temperature is outside 77 ±1.8°F.

14B. Finish filling the flask, place the metal or plastic cover or a glass plate on the flask, and eliminate all air from the flask.

25

26

Note 4: When using the metal flask and cover, place the cover on the flask and push down slowly, forcing excess water out of the hole in the center of the cover. Use care when filling flask to avoid reintroducing air into the water.

15B. Towel dry the outside of the flask and cover.

16B. Determine and record the mass of the flask, cover, de-aired water, and sample to the nearest 0.1 g. Designate this mass as "E" within 10 ±1 minutes of completion of Step 11.

17B. Mass "D", the mass of the flask and water, is determined during the Calibration of Flask procedure.

27

Procedure – Mixtures Containing Uncoated Porous Aggregate

28

If the pores of the aggregates are not thoroughly sealed by a bituminous film, they may become saturated with water during the vacuuming procedure, resulting in an error in maximum density.

To determine if this has occurred, complete the general procedure and then:

1. Drain water from sample through a towel held over top of container to prevent loss of material.

29

2. Spread sample before an electric fan to remove surface moisture.
3. Determine the mass of the sample when the surface moisture appears to be gone.
4. Continue drying and determine the mass of the sample at 15-minute intervals until less than a 0.5 g loss is found between determinations.
5. Record the mass as the saturated surface-dry mass to the nearest 0.1 g. Designate this mass as "A_{SSD}".
6. Calculate, as indicated below, G_{mm} using "A" and "A_{SSD}", and compare the two values.

Calculation

Calculate the G_{mm} to three decimal places as follows.

Bowl Procedure

30

$$G_{mm} = \frac{A}{A - C}$$

where:

A = mass of dry sample in air, g

C = submerged weight of sample in water, g

Example:

A = 1432.7 g

C = 848.6 g

$$G_{mm} = \frac{1432.7\,g}{1432.7\,g - 848.6\,g} = 2.453$$

Flask Procedure

$$G_{mm} = \frac{A}{A + D - E} \times R$$ OR 31

$$G_{mm} = \frac{A}{A_{SSD} + D - E} \times R$$

(for mixtures containing uncoated aggregate materials)

where:

A = Mass of dry sample in air, g

A_{SSD} = Mass of saturated surface-dry sample in air, g

D = Mass of flask filled with water at 77°F, g

E = Mass of flask filled with water and the test sample at test temperature, g

R = Factor from Table 2 to correct the density of water – used when a test temperature is outside 77 ±1.8°F.

Example (in which two increments are averaged):

Test 1	Test 2
A = 1200.3 g	A = 960.2 g
D = 7502.5 g	D = 7525.5 g
E = 8217.1 g	E = 8096.3 g
Temperature = 79.2°F	Temperature = 77.0°F

32

$$G_{mm_1} = \frac{1200.3\ \text{g}}{1200.3\ \text{g} + 7502.5\ \text{g} - 8217.1\ \text{g}} \times 0.99968 = 2.470$$

$$G_{mm_2} = \frac{960.2\,\text{g}}{960.2\,\text{g} + 7525.5\,\text{g} - 8096.3\,\text{g}} \times 1.00000 = 2.466$$

Allowable variation is: 0.011 for the Flask method and 0.018 for the Bowl method

2.470 - 2.466 = 0.004, which is < 0.011, so they can be averaged.

Average

2.470 - 2.466 = 0.004 0.004 ÷ 2 = 0.002 0.002 + 2.466 = **2.468**

Or 2.470 + 2.466 = 4.936 4.936 ÷ 2 = **2.468**

Table 2

Temperature Correction Factor

°C	°F	"R"		°C	°F	"R"
20.0	68.0	1.00117		23.3	74.9	1.00042
20.1	68.2	1.00114		23.4	74.1	1.00040
20.2	68.4	1.00112		23.5	74.3	1.00037
20.3	68.5	1.00110		23.6	74.5	1.00035
20.4	68.7	1.00108		23.7	74.7	1.00033
20.5	68.9	1.00106		23.8	74.8	1.00030
20.6	69.1	1.00104		23.9	75.0	1.00028
20.7	69.3	1.00102		24.0	75.2	1.00025
20.8	69.4	1.00100		24.1	75.4	1.00023
20.9	69.6	1.00097		24.2	75.6	1.00020
21.0	69.8	1.00095		24.3	75.7	1.00018
21.1	70.0	1.00093		24.4	75.9	1.00015
21.2	70.2	1.00091		24.5	76.1	1.00013
21.3	70.3	1.00089		24.6	76.3	1.00010
21.4	70.5	1.00086		24.7	76.5	1.00007
21.5	70.7	1.00084		24.8	76.6	1.00005
21.6	70.9	1.00082		24.9	76.8	1.00002
21.7	71.1	1.00080		25.0	77.0	1.00000
21.8	71.2	1.00077		25.1	77.2	0.99997
21.9	71.4	1.00075		25.2	77.4	0.99995
22.0	71.6	1.00073		25.3	77.5	0.99992
22.1	71.8	1.00030		25.4	77.7	0.99989
22.2	72.0	1.00068		25.5	77.9	0.99987
22.3	72.1	1.00066		25.6	78.1	0.99984
22.4	72.3	1.00064		25.7	78.3	0.99981
22.5	72.5	1.00061		25.8	78.4	0.99979
22.6	72.7	1.00059		25.9	78.6	0.99976
22.7	72.9	1.00057		26.0	78.8	0.99973
22.8	73.0	1.00054		26.1	79.0	0.99971
22.9	73.2	1.00052		26.2	79.2	0.99968
23.0	73.4	1.00050		26.3	79.3	0.99965
23.1	73.6	1.00047		26.4	79.5	0.99963
23.2	73.8	1.00045		26.5	79.7	0.99960

Theoretical Maximum Density

33

To calculate the theoretical maximum density at 77°F use one of the following formulas. The density of water at 77°F = 62.245 lb/ft^3.

Theoretical maximum density lb/ft^3 = G_{mm} x 62.245 lb/ft^3

2.468 x 62.245 lb/ft^3 = 153.6 lb/ft^3

34

Report

Results shall be reported on standard forms approved for use by the agency. Report G_{mm} to three decimal places. Report the theoretical maximum density to 0.1 lb/ft^3.

35

Tips!

- Use a calibrated flask with known mass when filled, if using flask procedure.
- Check for absorption in uncoated aggregate.

REVIEW QUESTIONS

1. A mix with the largest aggregate size of 1in should use what size sample?

2. At what temperature should the sample be for testing?

3. Removing the entrapped air from the contents of the flask by a partial vacuum is done for how long?

4. How and why is the flask agitated?

PERFORMANCE EXAM CHECKLIST

THEORETICAL MAXIMUM SPECIFIC GRAVITY AND DENSITY OF HOT MIX ASPHALT PAVING MIXTURES
FOP FOR AASHTO T 209

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Sample reduced to correct size?	_____	_____
2. Particles carefully separated insuring that aggregate is not fractured?	_____	_____
3. After separation, fine aggregate particles not larger than 1/4in?	_____	_____
4. Sample at room temperature?	_____	_____
5. Mass of bowl or flask & cover determined to 0.1 g?	_____	_____
6. Mass of sample and bowl or flask & cover determined to 0.1 g?	_____	_____
7. Mass of sample calculated and conforms to required size?	_____	_____
8. Water at approximately 77°F added to cover sample?	_____	_____
9. Entrapped air removed using partial vacuum for 15 ±2 min?	_____	_____
10. Container and contents agitated continuously by mechanical device or manually by vigorous shaking at intervals of about 2 minutes?	_____	_____
11. Bowl determination:		
a. Bowl and contents suspended in water at 77 ±1.8°F for 10 ±1 minutes?	_____	_____
b. Submerged weight of bowl and contents determined to 0.1 g?	_____	_____
c. Submerged weight of empty bowl determined to 0.1 g?	_____	_____
d. Net submerged weight of contents calculated?	_____	_____
12. Flask determination:		
a. Flask filled with water without reintroducing air into the sample?	_____	_____
b. Flask then placed in constant temperature water bath (optional)?	_____	_____
c. Contents at 77 ±1.8°F or temperature taken and Table 2 in FOP used?	_____	_____
d. Mass of filled flask determined to 0.1 g, 10 ±1 minutes after removal of entrapped air completed?	_____	_____

OVER

Procedure Element	**Trial 1**	**Trial 2**
e. Mass of flask and water obtained from the Calibration of Flask procedure?	_____	_____
13. G_{mm} calculated correctly and to 0.001?	_____	_____
14. Density calculated correctly and to 1 kg/m^3 (0.1 lb/ft^3)?	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

Examiner Signature _____WAQTC #:_____

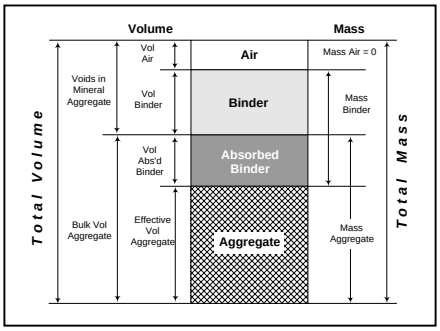
BULK SPECIFIC GRAVITY OF COMPACTED HOT MIX ASPHALT MIXTURES USING SATURATED SURFACE-DRY SPECIMENS FOP FOR AASHTO T 166

BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES USING PARAFFIN-COATED SPECIMENS FOP FOR AASHTO T 275

01

02

HMA core



03

HMA phase diagram

Significance

Compacted hot mix asphalt (HMA) includes voids that may contain gas, such as air, or liquid, such as water. The voids may be permeable, that is, they connect to the surface and can fill with water. They may also be impermeable, thus, filled only with air.

Because voids exist and contain air or water, the overall, or bulk, density of the compacted mix is less than the density of a theoretical mix of aggregate and binder having no voids. Thus, bulk density, and associated bulk specific gravity are indications of void and air content – both of which impact various properties of bituminous roadways.

Bulk specific gravity is the ratio of the mass of a given volume of dry, compacted mix at 77°F in air to the mass of an equal volume of water at the same temperature. The weight of the sample in water is subtracted from the mass of a saturated surface-dry (SSD) sample in air in order to determine the mass of the water displaced by the specimen. The measurement of void volume, which includes permeable internal and surface pores occupied by water, is useful for mix quality control because it takes into consideration the volume of voids permeable to water within the specimen.

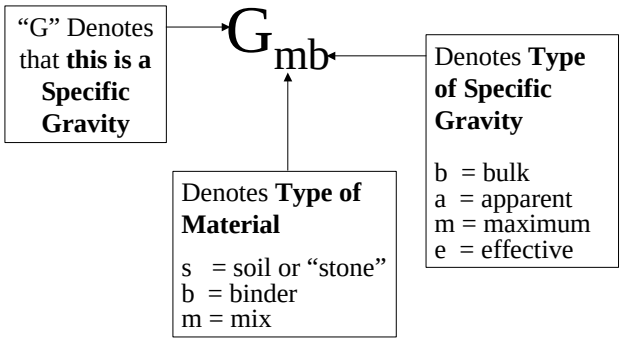
Scope

04

This procedure covers the determination of bulk specific gravity (G_{mb}) of compacted HMA using three methods – A, B, and C – in accordance with AASHTO T 166. These three methods are for use on specimens not having open or inter-connecting voids and/or not absorbing more than 2.0 percent water by volume. A fourth and fifth method – D & E – in accordance with AASHTO T 275 and covering specimens having open or interconnecting voids and / or absorbing more than 2.0 percent water by volume is also included.

05

Definition: (Specific Gravity Symbols)



Overview

- Method A Suspension
- Method B Volumeter

06

- Method C Rapid test for A or B
- Method D Suspension for coated specimen
- Method E Volumeter for coated specimen

Test Specimens

Test specimens may be either laboratory-molded or from HMA pavement. For specimens it is

07

recommended that the diameter be equal to four times the maximum size of the aggregate and the thickness be at least one and one half times the maximum size of the aggregate.

08

Apparatus – Method A (Suspension)

- Balance or scale: 5 kg capacity, readable to 0.1 g, fitted with a suitable suspension apparatus and holder to permit weighing the specimen while suspended in water and conforming to AASHTO M 231.

09

- Suspension apparatus: Wire of the smallest practical size and constructed to permit the container to be fully immersed.
- Water bath: For immersing the specimen in water while suspended under the balance or scale, and equipped with an overflow outlet for maintaining a constant water level.
- Towel: Damp towel used for surface drying specimens.
- Oven: Capable of maintaining a temperature of 125 ±5°F for drying the specimens to a constant mass.

Note 1: AASHTO T 166 defines constant mass as the mass that further drying at 125 ±5°F does not alter the mass by more than 0.05 percent. It also states that samples shall initially be dried overnight and that mass determinations shall be made at 2-hour drying intervals. AASHTO T 166 also states that recently molded laboratory samples that have not been exposed to moisture do not need drying.

- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Thermometer: Having a range of 66 to 80°F, graduated in 0.2°F subdivisions.

Procedure - Method A (Suspension)

10

1. Dry the specimen to constant mass, if required. See note #1.

Note 2: To expedite the procedure steps 1 and 2 may be performed last. To further expedite the process see Method C.

2. Cool the specimen in air to 77 ±9°F, and determine and record the dry mass to the nearest 0.1 g. Designate this mass as "A".
3. Fill the water bath to overflow level with water at 77 ±1.8°F.
4. Immerse the specimen for 4 ±1 minutes.
5. Determine and record the submerged weight to the nearest 0.1 g. Designate this submerged weight as "C".
6. Remove the sample from the water and quickly (not to exceed 5 seconds) surface dry with a damp towel.

11

Immersing specimen

12 7. Determine and record the mass of the SSD specimen to nearest 0.1 g. Designate this mass as "B". Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen.

Calculations - Method A (Suspension)

13

$$G_{mb} = \frac{A}{B - C}$$

where:

G_{mb} = Bulk Specific Gravity

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

C = Weight of specimen in water, g

$$\text{Percent Water Absorbed (by volume)} = \frac{B - A}{B - C} \times 100$$

Apparatus – Method B (Volumeter)

- Balance or scale: 5 kg capacity, readable to
14 0.1 g and conforming to AASHTO M 231.
- Water bath: thermostatically controlled to 77 ±0.9°F
- Thermometer: Range of 66 to 80°F, and graduated in 0.2°F subdivisions
- Volumeter: Calibrated to 1200 mL or appropriate capacity for test sample and having a tapered lid with a capillary bore

- Oven: Capable of maintaining a temperature of 125 ±5°F for drying the specimens to a constant
15 mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Towel: Damp towel used for surface drying specimens.

16

Procedure - Method B (Volumeter)

1. Dry the specimen to constant mass if required. See note 1.

Note 2: To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process see Method C.

2. Cool the specimen in air to 77 ±9°F, and determine and record the dry mass to the nearest 0.1 g. Designate this mass as "A".

Drying surface

17

3. Immerse the specimen in the temperature controlled water bath for at least 10 minutes.
4. Fill the volumeter with distilled water at 77 ±1.8°F making sure some water escapes through the capillary bore of the tapered lid. Wipe the volumeter dry. Determine the mass of the volumeter to the nearest 0.1 g. Designate this mass as "D".

18

5. At the end of the ten-minute period, remove the specimen from the water bath and quickly (within 5 seconds) surface dry with damp towel.

19

6. Determine and record the mass of the SSD specimen to nearest 0.1 g. Designate this mass as "B". Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen.

20

7. Place the specimen in the volumeter and let stand 60 seconds.
8. Bring the temperature of the water to 77 ±1.8°F, and cover the volumeter making sure some water escapes through the capillary bore of the tapered lid.
9. Wipe the volumeter dry.

21

10. Determine and record the mass of the volumeter and specimen to the nearest 0.1 g. Designate this mass as "E".

Note 3: Method B is not acceptable for use with specimens that have more than 6 % air voids.

Calculations - Method B (Volumeter)

22

$$G_{mb} = \frac{A}{B + D - E}$$

where:

G_{mb} = Bulk Specific Gravity

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

D = Mass of volumeter filled with water at 77 ±1.8°F, g

E = Mass of volumeter filled with specimen and water, g

$$\%\,\text{Water Absorbed (by volume)} = \frac{\text{B - A}}{\text{B + D − E}} \times 100$$

23

Apparatus - Method C (Rapid Test for Method A or B)

See Methods A or B.

Note 4: This procedure can be used for specimens not required to be saved and that contain substantial amounts of moisture. Cores can be tested the same day as obtained by this method.

Procedure – Method C (Rapid Test for Method A or B)

24

1. Determine which method to perform, A or B. Proceed with Method A or B, except that the dry mass, A, is determined last. In method A and B, start on step 3, complete that procedure then continue as follows to determine mass "A".
2. Place the specimen on a large, flat bottom pan of known mass.
3. Heat at a minimum of 221°F, until the specimen can be easily separated to the point where the fine aggregate particles are not larger than 1/4 in. In no case should the Job Mix Formula mixing temperature be exceeded.

25

4. Dry to constant mass. Constant mass is defined as the mass at which further drying at the temperature in step 3 does not change by more

than 0.05% after an additional 2 hour drying time.

5. Cool in air to 77 ±9°F.
6. Determine and record the mass of the pan and specimen to the nearest 0.1 g.
7. Determine and record the mass of the dry specimen to the nearest 0.1 g by subtracting the mass of the pan from the mass determined in Step 6. Designate this mass as "A".

Calculations – Method C (Rapid Test for Method A or B)

Complete the calculations as outlined in Methods A or B, as appropriate.

Materials – Method D Suspension (Coated Specimens/AASHTO T 275)

- Paraffin or parafilm: Used to coat test specimens.

Apparatus – Method D Suspension (Coated Specimens/AASHTO T 275)

- Balance or scale: 5 kg capacity, readable to 0.1 g, fitted with a suitable suspension apparatus and holder to permit weighing the specimen while suspended in water and conforming to AASHTO M 231.
- Suspension apparatus: Wire of the smallest practical size and constructed to permit the container to be fully immersed.
- Water bath: For immersing the specimen in water while suspended under the balance or scale, and equipped with an overflow outlet for maintaining a constant water level.
- Oven: Capable of maintaining a temperature of 125 ±5°F for drying the specimens to a constant mass. See note 1.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.

30

Procedure - Method D Suspension (Coated Specimens/AASHTO T 275)

1. Dry the specimen to constant mass, if required. See note 1.
2. Cool the specimen in air to 77 ±9°F, and determine and record the dry mass to the nearest 0.1 g. Designate this mass as "A".
3. Coat specimen on all surfaces with melted paraffin, or parafilm coating, sufficiently thick to seal all voids.
4. Allow coating to cool in air to 77 ±9°F for 30 minutes.
5. Determine and record the mass of the coated specimen to the nearest 0.1 g. Designate this mass as "D".

31

6. Fill the water bath to overflow level with water at 77 ±1.8°F.
7. Immerse the specimen in water at 77 ±1.8°F for 4 ±1 minutes.

32

8. Determine and record the submerged weight to the nearest 0.1 g. Designate this submerged weight as "E".
9. Determine the specific gravity of paraffin or parafilm at 77 ±1.8°F from the manufacturer's literature or other suitable source. Designate this specific gravity as "F".

Calculations - Method D Suspension (Coated Specimens/AASHTO T 275)

33

$$G_{mb} = \frac{A}{D - E - \left[\frac{D - A}{F}\right]}$$

where:

G_{mb} = Bulk Specific Gravity

A = Mass of dry specimen in air, g

D = Mass of specimen with paraffin coating in air, g

E = Weight of specimen with paraffin coating in water, g

F = Specific gravity of paraffin or parafilm at 77 ±1.8°F

Apparatus – Method E Volumeter (Coated Specimens/AASHTO T 275)

34

- Balance or scale: 5 kg capacity, readable to 0.1 g and conforming to AASHTO M 231.
- Water bath: thermostatically controlled to 77 ±0.9°F.
- Thermometer: Range of 66 to 80°F, and graduated in 0.2°F subdivisions.
- Volumeter: Calibrated to 1200 mL or appropriate capacity for test sample and having a tapered lid with a capillary bore.
- Oven: Capable of maintaining a temperature of 125 ±5°F for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.

Procedure - Method E Volumeter (Coated Specimens/AASHTO T 275)

1. Dry the specimen to constant mass. See note 1.
2. Cool the specimen in air to 77 ±9°F, and determine and record the dry mass to the nearest 0.1 g. Designate this mass as "A".
3. Coat the specimen all surfaces with paraffin, or parafilm coating, sufficiently thick to seal all voids.
4. Allow coating to cool in air at 77 ±9°F for 30 minutes.
5. Determine and record the mass of the coated specimen to the nearest 0.1g. Designate this mass as "C".
6. Fill the volumeter with distilled water at 77 ±1.8°F and place the coated specimen in the volumeter.
7. Bring the temperature of the water to 77 ±1.8°F, and cover the volumeter making sure some water escapes through the capillary bore of the tapered lid.
8. Wipe the volumeter dry.
9. Determine and record the mass of the volumeter and specimen to the nearest 0.1 g. Designate this mass as "E".
10. Determine the specific gravity of paraffin or parafilm at 77 ±1.8°F from the manufacturer's literature or other suitable source. Designate this specific gravity as "F".

Calculations - Method E Volumeter (Coated Specimens/AASHTO T 275)

39

$$G_{mb} = \frac{A}{D - \left[E - C + \left(\frac{C - A}{F} \right) \right]}$$

where:

G_{mb} = Bulk Specific Gravity

A = Mass of dry specimen in air, g

C = Mass of specimen with paraffin coating in air, g

D = Mass of volumeter filled water at 77 ±1.8°F, g

E = Mass of volumeter filled with specimen with paraffin coating and water at 77 ±1.8°F, g

F = Specific gravity of paraffin or parafilm at 77 ±1.8°F

Report

40

Results shall be reported on standard forms approved for use by the agency. Report the G_{mb} to 3 decimal places and absorption to 2 decimal places. Report the method performed.

Tips!

41

- Use method approved by agency.
- Check for open or interconnecting voids and/or absorption over 2.0 percent. Use Method D or E, if appropriate.
- Check temperature of water in water bath.

REVIEW QUESTIONS

1. For how long must samples be submerged prior to determining immersed weight for Method A?

2. In determining SSD mass of a specimen, how must the sample be dried?

3. At what temperature and for how long should cored samples be dried?

4. How do methods A and B differ?

PERFORMANCE EXAM CHECKLIST

BULK SPECIFIC GRAVITY OF COMPACTED HOT MIX ASPHALT USING SATURATED SURFACE-DRY SPECIMENS
FOP FOR AASHTO T 166

BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES USING PARAFFIN-COATED SPECIMENS
FOP FOR AASHTO T 275

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
Method A:		
1. Mass of dry sample in air determined.		
a. Dried overnight at 125 ±5°F and at successive 2-hour intervals to constant mass?	_____	_____
b. Cooled in air to, 77 ±9°F?	_____	_____
c. Dry mass determined to 0.1g?	_____	_____
2. Water at the overflow?	_____	_____
3. Immersed weight determined.		
a. Water at 77 ±1.8°F?	_____	_____
b. Immersed at 4 ±1 minutes?	_____	_____
c. Immersed weight determined to 0.1g	_____	_____
4. Sample rapidly surface dried with damp cloth?	_____	_____
5. Saturated surface-dry (SSD) mass determined to 0.1g?	_____	_____
6. G_{mb} calculated to 0.001?	_____	_____
7. Calculate percent water absorbed determined to be less than 2.0 percent?	_____	_____
Method B:		
1. Specimen dried, cooled, and mass determined as in Method A?	_____	_____
2. Saturated surface-dry (SSD) mass determined to 0.1g.		
a. Immersed at least 10 minutes at 77 ±1.8°F?	_____	_____
b. Sample rapidly dried with damp towel?	_____	_____
c. Specimen mass determined to 0.1g?	_____	_____
d. Any water that seeps from specimen included in mass?	_____	_____

OVER

Procedure Element	**Trial 1**	**Trial 2**
3. Mass of volumeter filled with distilled water at 77 ±1.8°F determined?	_____	_____
4. SSD specimen placed into volumeter and let stand for 1 minute?	_____	_____
5. Temperature of water brought to 77 ±1.8°F and volumeter covered, allowing some water to escape through the capillary bore of the tapered lid?	_____	_____
6. Volumeter wiped dry, and mass of volumeter and contents determined?	_____	_____
7. G_{mb} calculated to 0.001?	_____	_____
8. Calculate percent water absorbed determined to be less than 2.0 percent?	_____	_____
Method C/A:		
1. Immersed weight determined.		
a. Water at 77 ±1.8°F?	_____	_____
b. Immersed at 4 ±1 minutes?	_____	_____
c. Immersed weight determined to 0.1g?	_____	_____
2. Sample rapidly surface dried with damp cloth?	_____	_____
3. Saturated surface-dry mass determined to 0.1g?	_____	_____
4. Dry mass determined by:		
a. Heating in oven at a minimum of 221°F?	_____	_____
b. Breaking down to1/4 in. particles?	_____	_____
c. Drying in oven to constant mass (change less than 0.05 percent in 2-hours of additional drying)?	_____	_____
d. Cooled in air to 77 ±9°F and mass determined to 0.1g?	_____	_____
5. G_{mb} calculated to 0.001?	_____	_____
6. Calculated percent water absorbed determined to be less than 2.0 percent?	_____	_____
Method C/B:		
1. Saturated surface-dry (SSD) mass determined to 0.1g.		
a. Immersed at least 10 minutes at 77 ±1.8°F?	_____	_____
b. Sample rapidly dried with damp towel?	_____	_____
c. Specimen mass determined to 0.1g?	_____	_____
d. Any water that seeps from specimen included in mass?	_____	_____
2. Mass of volumeter filled with distilled water at 77 ±1.8°F determined to 0.1g?	_____	_____

OVER

Procedure Element	Trial 1	Trial 2
3. SSD specimen placed into volumeter and let stand for 1 minute?	_____	_____
4. Temperature of water brought to 77 ±1.8°F and volumeter covered, allowing some water to escape through the capillary bore of the tapered lid?	_____	_____
5. Volumeter wiped dry, and mass of volumeter and contents determined to 0.1g?	_____	_____
6. Dry mass determined by:		
a. Warming in oven at a minimum of 221°F?	_____	_____
b. Breaking down to 1/4 in. particles?	_____	_____
c. Drying in oven to constant mass (change less than 0.05 percent in 2-hours of additional drying)?	_____	_____
d. Cooled in air to 77 ±9°F and mass determined to 0.1g?	_____	_____
7. G_{mb} calculated to 0.001?	_____	_____
8. Calculated percent water absorbed determined to be less than 2.0 percent?	_____	_____
Method D:		
1. Mass of dry sample in air determined to 0.1g.		
a. Dried overnight at 125 ±5°F and at successive 2-hour intervals to constant mass?	_____	_____
b. Cooled in air to 77 ±9°F?	_____	_____
c. Mass of dry sample determined to 0.1g?	_____	_____
2. Specimen sufficiently coated to seal all voids and cooled for 30 minutes?	_____	_____
3. Mass of coated specimen determined to 0.1g?	_____	_____
4. Immersed weight determined to 0.1g.		
a. Water at 77 ±1.8°F?	_____	_____
b. Immersed at 4 ±1 minutes?	_____	_____
c. Immersed weight determined 0.1g?	_____	_____
5. Specific Gravity of coating determined?	_____	_____
6. G_{mb} calculated to 0.001?	_____	_____
Method E:		
1. Mass of dry sample in air determined to 0.1g?		
a. Dried overnight at 125 ±5°F and at successive 2-hour intervals to constant mass (or by other means, if allowed)?	_____	_____
b. Cooled in air to, 77 ±9°F?	_____	_____
c. Mass of dry sample determined to 0.1g?	_____	_____

OVER

Procedure Element	**Trial 1**	**Trial 2**
2. Specimen sufficiently coated to seal all voids and cooled for 30 minutes?	_____	_____
3. Mass of coated specimen determined to 0.1g?	_____	_____
4. Mass of volumeter filled with distilled water at 77 ±1.8°F determined to 0.1g?	_____	_____
5. SSD specimen placed into volumeter?	_____	_____
6. Temperature of water brought to 77 ±1.8°F and volumeter covered, allowing some water to escape through the capillary bore of the tapered lid and let stand for 1 minute?	_____	_____
7. Volumeter wiped dry, and mass of volumeter and contents determined to 0.1g?	_____	_____
8. G_{mb} calculated to 0.001?	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

Examiner Signature _____WAQTC #:_____

SAMPLING BITUMINOUS MATERIALS
FOP FOR AASHTO T 40

01

Significance

The quality of bituminous materials has a tremendous impact on a roadway project. The grade of binder selected is based on a number of factors, including local temperature extremes and characteristics of expected traffic. Using a grade of binder material other than that specified will have serious impacts on roadway performance and durability.

02

Scope

The procedure covers obtaining samples of liquid bituminous materials in accordance with AASHTO T 40. Sampling of solid and semi-solid bituminous materials – included in AASHTO T 40 – is not covered here.

Agencies may be more specific on exactly who samples, where to sample, and what type of sampling device to use.

Procedure

03

1. Coordinate sampling with contractor or supplier.
2. Use appropriate safety equipment and precautions for hot liquids.
3. Allow a minimum of 1 gal to flow before obtaining a sample(s).

04

4. Obtain samples of:
   - Asphalt binder from Hot Mix Asphalt (HMA) Plant: from the line between the storage tank and the mixing plant while the plant is in operation, or from the delivery truck.
   - Cutback and Emulsified asphalt from distributor spray bar or application device or from the delivery truck before it is pumped into the distributor: Sample emulsified asphalt at delivery or prior to dilution.

05

Sampling liquid binder

Containers

Sample containers must be new, and the inside may not be washed or rinsed. The outside may be wiped with a clean, dry cloth.

06 All samples shall be put in 1 qt containers and properly identified on the outside of the container with contract number, date sampled, data sheet number, brand and grade of material, and sample number. Include lot and sublot numbers when appropriate.

07
- Emulsified asphalt: Use wide-mouth plastic jars with screw caps. Protect the samples from freezing since water is a part of the emulsion. The sample container should be completely filled to minimize a skin formation on the sample.

- Asphalt binder and Cutbacks: Use metal cans.

Note: The filled sample container shall not be submerged in solvent, nor shall it be wiped with a solvent saturated cloth. If cleaning is necessary, use a clean dry cloth.

Tips!

08
- Remember to identify sample on outside of container.

REVIEW QUESTIONS

1. Describe how liquid bituminous material is obtained at an HMA plant.

2. Describe how liquid bituminous material is obtained from a spray distributor.

3. Describe the containers used for sampling.

PERFORMANCE EXAM CHECKLIST (ORAL)

SAMPLING BITUMINOUS MATERIALS
FOP FOR AASHTO T 40

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Describe the container that is used to sample bituminous liquids.		
a. New metal can, 1 qt in size.	_____	_____
2. Describe the container that is used to sample emulsified liquids.		
a. New wide mouth plastic jar, 1 qt in size.	_____	_____
3. How much material must be wasted before a sample can be obtained?		
a. A minimum of 1 gal.	_____	_____
4. At a hot plant where must a sample be taken?		
a. In the line between storage tank and mixing plant or from delivery vehicle.	_____	_____
5. Where is an emulsified sample taken?		
a. Spray bar or application device, if not diluted.	_____	_____
b. From delivery vehicle or prior to dilution, if diluted.	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

_____

_____

_____

_____

_____

_____

_____

_____

Examiner Signature _____WAQTC #:_____

PERFORMANCE EXAM CHECKLIST

SAMPLING BITUMINOUS MATERIALS
FOP FOR AASHTO T 40

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

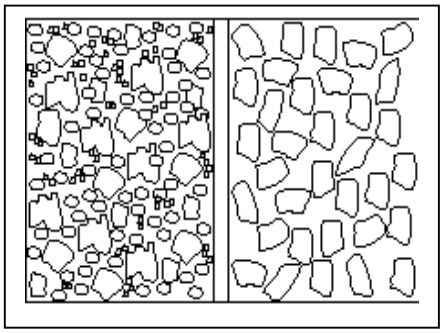
Procedure Element	**Trial 1**	**Trial 2**
1. Appropriate containers used?		
a. Wide-mouth plastic containers (emulsified).	_____	_____
b. Metal cans (all other bituminous liquids).	_____	_____
2. Containers <u>not</u> washed or rinsed on inside?	_____	_____
3. Minimum of 1 gal allowed to flow before sample taken?	_____	_____
4. Material obtained at correct location?		
a. Line between storage tank and mixing plant or from delivery vehicle (HMA plants).	_____	_____
b. Spray bar or application device, if not diluted (distributors).	_____	_____
c. From delivery vehicle or prior to dilution, if diluted (distributors).	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

_____
_____
_____
_____
_____
_____
_____
_____

Examiner Signature _____WAQTC #:_____

MECHANICAL ANALYSIS OF EXTRACTED AGGREGATE FOP FOR AASHTO T 30



Well- vs. uniformly graded

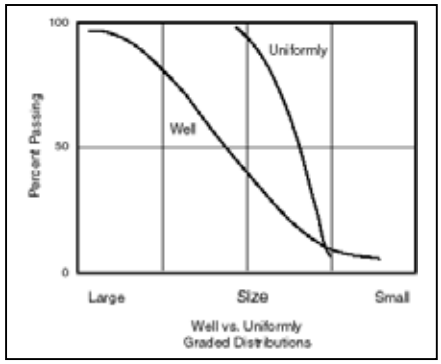
01

02

03

Significance

The amount and gradation of aggregate in bituminous paving mixes are specified by the agency and relate to strength, flexibility, and durability considerations. Mix designs are based on those specifications, as is mix production. To confirm that the amount and gradation of aggregate in the finished product are correct, tests must be conducted. Compliance with the specification will help ensure a good roadway. Non-compliance may result in failure of the roadway. For these reasons, analysis of aggregate in bituminous mixes is extremely important.



Gradation curves

04

05

Scope

This procedure covers mechanical analysis of aggregate recovered from bituminous mix samples in accordance with AASHTO T 30. This FOP utilizes the aggregate recovered from the ignition oven used in AASHTO T 308. AASHTO T 30 was developed for analysis of extracted aggregate and, thus, includes references to extracted bitumen and filter element, which do not apply in this FOP.

Sieve analyses determine the gradation or distribution of aggregate particles within a given sample in order to determine compliance with design and production standards.

Apparatus

Apparatus

- Balance or scale: capacity sufficient for the sample mass, accurate to 0.1 percent of the sample mass or readable to 0.1 g and conforming to AASHTO M 231.
- Sieves
- Mechanical sieve shaker
- Suitable drying equipment (see FOP for AASHTO T 255)
- Containers and utensils – a pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any part of the sample or water.

Sample Sieving

In this procedure it is required to shake the sample over nested sieves. The sieves are selected to furnish information required by specification. Sieves are nested in order of decreasing size from the top to the bottom and the sample, or a portion of the sample, is placed on the top sieve.

Hand shaking

Sieves are shaken in a mechanical shaker for approximately 10 minutes, or the minimum time determined to provide complete separation for the sieve shaker being used.

Time Evaluation

The minimum time requirement should be evaluated for each shaker at least annually, by the following method: Continue shaking for a sufficient period and in such a manner that, after completion, not more than 0.5 percent by mass of the total sample passes any sieve during one minute of continuous hand sieving.

Provide a snug-fitting pan and cover, and hold in a slightly inclined position in one hand. Strike the side of the sieve sharply and with an upward motion against the heel of the other hand at the

rate of about 150 times per minute, turning the sieve about one sixth of a revolution at intervals of about 25 strokes. In determining sufficiency of sieving for sizes larger than No. 4, limit the material on the sieve to a single layer of particles.

Overload Determination

11 Additional sieves may be necessary to keep from overloading the specified sieves. The sample may also be sieved in increments. For sieves with openings smaller than No. 4, the mass retained on any sieve shall not exceed 6 kg/m^2 (4 g/in^2) of sieving surface. For sieves with openings No. 4 and larger, the mass, in kg shall not exceed the product of 2.5 x (sieve opening in mm) x (effective sieving area). See Table 1.

TABLE 1

Maximum Allowable Mass of Material Retained on a Sieve, g

Nominal Sieve Size, (in.)

Exact size is smaller (see AASHTO T 27)

12

Sieve Size (in.)	8" ϕ	12" ϕ	12" x 12"	14" x 14"	16" x 24"
	Sieving Area m^2				
	0.0285	0.0670	0.0929	0.1225	0.2158
3½	*	15,100	20,900	27,600	48,500
3	*	12,600	17,400	23,000	40,500
2½	*	10,600	14,600	19,300	34,000
2	3600	8400	11,600	15,300	27,000
1½	2700	6300	8700	11,500	20,200
1	1800	4200	5800	7700	13,500
3/4	1400	3200	4400	5800	10,200
5/8	1100	2700	3700	4900	8600
1/2	890	2100	2900	3800	6700
3/8	670	1600	2200	2900	5100
1/4	440	1100	1500	1900	3400
No. 4	330	800	1100	1500	2600
-No. 4	200	470	0650	1200	1300

Procedure

13

1. Using the aggregate sample obtained from the FOP for AASHTO T 308, determine and record the mass of the sample to 0.1 g. This mass shall agree with the mass of the aggregate remaining after ignition (M_f from T 308) within 0.1%).

2. Nest a sieve, such as a No. 10, above the No. 200 sieve.

Separation of material

14

15

3. Place the test sample in a container and add sufficient water to cover it. Add a detergent, dispersing agent, or other wetting solution to the water to assure a thorough separation of the material finer than the No. 200 sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.

4. Agitate vigorously to ensure complete separation of the material finer than No. 200 from coarser particles and bring the fine material into suspension above the coarser material.

Pouring suspension through sieves

16

17

5. Immediately pour the wash water containing the suspended and dissolved solids over the nested sieves, being careful not to pour out the coarser particles.

6. Add a second change of water to the sample remaining in the container, agitate, and repeat Step 5. Repeat the operation until the wash water is reasonably clear. Continue washing until the agent is removed.

7. Rinse the material retained on the nested sieves until water passing through the sieve is reasonably clear.

18

8. Remove the upper sieve and rinse the material retained on the No.200 sieve until water passing through the sieve is reasonably clear.

9. Return all material retained on the nested sieves to washed sample by flushing with water.

10. Dry the washed aggregate to constant mass in accordance with the FOP for AASHTO T 255, and then cool prior to sieving. Record the "dry mass after washing".

19

Small sieve shaker

20

11. Select sieves to furnish information required by the specifications. Nest the sieves in order of decreasing size from top to bottom and place the sample, or a portion of the sample, on the top sieve.

21

12. Place sieves in mechanical shaker and shake for the minimum time determined to provide complete separation for the sieve shaker being used, approximately 10 minutes.

Note 1: Excessive shaking (more than 10 minutes) may result in degradation of the sample.

22

Brushing sieve

13. Determine the mass retained (individual/ cumulative) on each sieve to the nearest 0.1 g. Ensure that all material trapped in the openings of the sieves are cleaned out and included in the mass retained.

23

Note 2: Use coarse wire brushes to clean the No. 30 and larger sieves, and soft bristle brushes for smaller sieves.

24

Calculation

1. The total mass of the material after sieving should check closely with the original mass of sample placed on the sieves (dry mass after washing). When the masses before and after sieving differ by more than 0.2 percent do not use the results for acceptance purposes
2. Divide the masses for each sieve (individual/ cumulative) by the total dry mass before washing and multiply by 100 to determine the percent retained on and passing each sieve. Calculate the percent retained and passing each sieve to the nearest 0.1%.
3. Apply the Aggregate Correction Factor to the calculated percent passing, as required in the FOP for AASHTO T 308 "Correction Factor" Steps 10 through 12, to obtain the reported percent passing. Report percentages to the nearest 1% except for the percent passing the No. 200 sieve, which shall be reported to the nearest 0.1%.

25

PERCENT RETAINED:

Where:

IPR= Individual Percent Retained

CPR= Cumulative Percent Retained 26, 27, 28

M=Total Dry Sample mass before washing

IMR= Individual Mass Retained

CMR= Cumulative Mass Retained

$$IPR = \frac{IMR}{M} X100 \quad \textbf{OR} \quad CPR = \frac{CMR}{M} X100$$

PERCENT PASSING and REPORTED PERCENT PASSING:

Where:

PP= Calculated Percent Passing [29]

PCP= Previous Calculated Percent Passing

RPP= Reported Percent Passing

PP = PCP - IPR or PP = 100 - CPR

RPP = PP + Aggregate Correction Factor

Example:

Dry mass of total sample, before washing: 2422.3 g
Dry mass of sample, after washing out the No. 200 minus: 2296.2 g
Amount of No. 200 minus washed out: 2422.3 – 2296.2 g = 126.1 g

Percent Retained No. 200 [30, 31, 32]

$$2.6\% = \frac{63.5}{2422.3} X 100 \quad \text{or} \quad 95.5\% = \frac{2289.6}{2422.3} X 100$$

Percent Passing 5.5% = 8.1 - 2.6 or 5.5% = 100 - 94.5

Reported Percent Passing 4.9% = 5.5 + (-0.6)

Gradation on All Screens

Sieve Size (in.)	Mass Retained, g (MR)	Percent Retained (PR)	Cumulative Mass Retained (CMR)	Cum. Percent Retained (CPR)	Calc'd Percent Passing (PP)	Agg. Corr. Factor T-308 (ACF)	Reported Percent Passing (RPP)
3/4	0.0		0.0	0	100.0		100
1/2	346.9	14.3	346.9	14.3	85.7		86
3/8	207.8	8.6	554.7	22.9	77.1		77
No. 4	625.4	25.8	1180.1	48.7	51.3		51
No. 8	416.2	17.2	1596.3	65.9	34.1		34
No. 16	274.2	11.3	1870.5	77.2	22.8		23
No. 30	152.1	6.3	2022.6	83.5	16.5		16
No. 50	107.1	4.4	2129.7	87.9	12.1		12
No. 100	96.4	4.0	2226.1	91.9	8.1		8
No. 200	63.5	2.6	2289.6	94.5	5.5	-0.6	4.9
Pan	5.7		2295.3				

Check sum: 2296.2 –2295.3 / 2296.2 X 100 = 0.04 % is within the 0.2 percent requirement.

Report

34 Results shall be reported on standard forms approved for use by the agency. Depending on the agency, this may include:

- Mass retained on each sieve
- Percent retained on each sieve
- Cumulative mass retained on each sieve
- Cumulative percent retained on each sieve
- Calculated Percent passing each sieve to 0.1%
- Aggregate Correction Factor for each sieve from AASHTO T 308
- Reported Percent passing

Report percentages to the nearest 1 percent except for the percent passing the No. 200 sieve, which shall be reported to the nearest 0.1 percent.

Tips!

- Do not lose any material when running the test.
- Remember to base calculations on the total mass of the initial dry sample.
- Check calculations for accuracy, and sieves for damage or plugging if results look “odd” or if the material suddenly goes out of spec.
- Save all material for rerunning.

35

36

REVIEW QUESTIONS

1. What is the maximum mass that can be retained on a No. 4 sieve with a 12” diameter?

2. Describe how sieves should be cleaned.

3. What should be done to protect the No. 200 sieve during washing?

4. Once a washed sample is placed in the oven and dried to a constant mass, what is the next step?

5. For how long should material be sieved on the shaker?

6. How much unexplained sample mass may be lost before you would have to rerun an aggregate sample?

PERFORMANCE EXAM CHECKLIST

MECHANICAL ANALYSIS OF EXTRACTED AGGREGATE FOP FOR AASHTO T 30

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	Trial 1	Trial 2
1. Total dry mass determined to 0.1 g	_____	_____
2. Dry mass agrees with sample mass after ignition (M_f) from AASHTO T 308 within 0.1%?	_____	_____
3. Sample placed in container and covered with water?	_____	_____
4. Wetting agent added?	_____	_____
5. Contents of container agitated vigorously?	_____	_____
6. Wash water poured through proper nest of two sieves?	_____	_____
7. Washing continued until wash water is clear and no wetting agent remaining?	_____	_____
8. Retained material returned to washed sample?	_____	_____
9. Washed material coarser than No. 200 dried to constant mass at 230 ±9°F?	_____	_____
10. Sample cooled to room temperature?	_____	_____
11. Dry mass after washing determined to 0.1 g?	_____	_____
12. Material sieved on specified sieves?	_____	_____
13. Mass of each fraction of aggregate, including minus No. 200, determined and recorded to 0.1 g?	_____	_____
14. Percent passing on each sieve determined correctly to the nearest 0.1%.?	_____	_____
15. Aggregate correction factor applied?	_____	_____
16. Percent passing on each sieve reported correctly to the nearest 1% and nearest 0.1% on the No. 200?	_____	_____
17. Does summation of sieve masses check total washed dry mass to within 0.2 percent?	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

_____

_____

_____

Examiner Signature _____WAQTC #:_____

STANDARD METHOD OF TEST FOR PREPARING AND DETERMINING THE DENSITY OF THE HOT MIX ASPHALT (HMA) SPECIMENS BY MEANS OF THE SUPERPAVE GYRATORY COMPACTOR
FOP FOR AASHTO T 312

02

Scope

The Superpave gyratory compactor is used to compact cylindrical specimens of hot-mix asphalt (HMA) by means of gyrations under a specified compressive stress and angle of inclination.

03

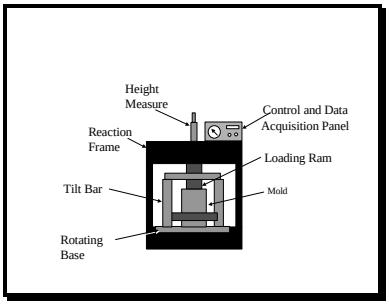
Significance

The procedure covers preparing specimens for determining the mechanical and volumetric properties of HMA. This procedure may also be used for field control of an HMA production process.

04

Apparatus

- Superpave Gyratory Compactor with specimen height measurement and recording device
- Molds (150 mm x 250 mm)
- Chute
- Scale
- Oven
- Miscellaneous



05

Gyratory Components

Refer to AASHTO T 312

- Reaction Frame
  - Rotating base and Motor
- Loading System
  - Ram and Pressure gauge
- Height measure and recordation
- Molds, etc.

06

Standardization

Calibration should be periodically verified on:

- Ram pressure
- Angle of gyration
- Gyration frequency
- Specimen height recording device
- Mold and plates

Angle of gyration may refer to either external angle or internal angle. The external angle is the tilt of the mold in respect to a plane external to the mold. The internal angle is the tilt of the mold with respect to the end plate surface within the mold.

External and internal angles are not considered equivalent. The calibration and verification should be performed appropriate to the measurement desired. External angle should be verified using manufacturer's recommendations. Internal angle is verified in accordance with AASHTO PP 48.

07

Equipment Preparation

Equipment preparation should be performed in accordance with manufacturer's recommendations, these should include:

- Warm-up equipment
- Verify settings
  - Angle
  - Pressure
  - Number of gyrations
- Lubricate bearing surfaces
- Prepare recording device
- Pre-heat molds and plates at compaction temperature (minimum of 30 min.)
- Pre-heat chute, spatulas and other apparatus (not to exceed compaction temperature, but may be lower to prevent damaging equipment)

08

Sample Preparation

Laboratory Prepared HMA

If laboratory mixed, prepare in accordance with AASHTO R 30. If the specimens are to be used for the determination of volumetric properties, the sample size should be adjusted to result in a compacted specimen that is 115 ±5mm at the desired number of gyrations. It may be necessary to produce a trial specimen to determine the approximate testing size.

Plant produced HMA

Sample should be obtained in accordance with T 168 and reduced to testing size in accordance with T 328. The sample shall be brought to the compaction temperature range by careful, uniform heating in an oven immediately prior to molding.

Compaction Procedure

Superpave gyratory compactors may be different from that shown. Follow the manufacturers recommended loading procedure. This may require the steps performed in an order other than that discussed, i.e. if the mold is placed in a Pine / Brovold compactor prior to material loaded into the mold.

09

1. Remove pre-heated mold and plate(s) from the oven.
2. Place base plate and paper disc in bottom of mold.

10

Note: Ensure plate(s) are correctly placed in the mold.

3. Mix sample with a heated spatula until it appears homogenous.

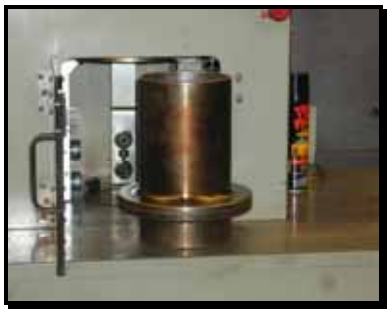
11

4. Pour the mix into the mold all at once (care should be taken to avoid segregation or loss of material).

12

5. Level the mix in the mold.
6. Place a paper disc and the heated top-plate (if required) on top of leveled sample.

13



14

7. Load the mold into the compactor.
8. Ensure compactor is set to the specified number of gyrations or required specimen height.
9. Apply pressure: 600 kPa ±18 kPa
10. Set angle: 1.25 ± 0.02° external angle, 1.16 ±0.02° average internal angle.
11. Apply the specified number of gyrations.

15

Once the compaction is complete (after the specified number of gyrations), the compacted specimen is extruded from the mold and the paper discs removed. The compressed sample is then cooled down to room temperature, and the specimen is appropriately identified.

Note: A cooling period of 5-10 min. in front of a fan may be necessary for some HMA before extruding to insure the specimens are not damaged.

When reusing the mold it should be re-heated for a minimum of 5 minutes.

16

Density Procedure

Determine maximum specific gravity (G_{mm}) of the loose mix in accordance with AASHTO T 209 using a companion sample. Laboratory samples shall be prepared and conditioned in accordance with the FOP for R 30. If mix is plant produced conditioning is not required.

Determine the bulk specific gravity (G_{mb}) of the compacted specimen in accordance with AASHTO T 166/T 275.

To calculate density, obtain the recorded specimen height to the nearest 0.1 mm after each revolution. This may be a printout or via computer data acquisition software.

Uncorrected Relative Density

The measured heights are used to calculate the density of the sample during the compaction process. These densities are referred to as the "uncorrected density" because they are estimated based on exact volume calculations. The formulas calculate volume in cm^3 to allow direct comparison with the specific gravity.

17

$$\%G_{mmux} = \frac{W_m}{V_{mx}\ G_{mm}\ G_m} \times 100$$

and

$$V_{mx} = \frac{\pi\ d^2\ h_x}{4000}$$

The uncorrected relative density may be calculated at any point in the compaction process using the equations at the left.

where:

$\%G_{mmux}$ = uncorrected relative density
W_m = mass of the specimen in g
G_{mm} = theoretical maximum specific gravity
G_m = unit wt. of water ($1g/cm^3$)
x = number of gyrations
V_{mx} = specimen volume, in cm^3 at any point
based on diameter and height at that point (using mm for height and diameter)
h_x = height after x gyrations (mm)
d = diameter (mm)

Note: This formula gives the volume in cm^3 to allow a direct comparison with the specific gravity.

18

$$\%G_{mmx} = \frac{G_{mb}\ h_m}{G_{mm}\ h_x} \times 100$$

Corrected Relative Density

The corrected relative density ($\%G_{mmx}$) may be determined for any point in the compaction of the specimens by using the formula at the left

where:

$\%G_{mmx}$ = corrected relative density as percent of maximum theoretical specific gravity

G_{mb} = measured bulk specific gravity of the compacted specimen

h_m = height of extruded specimen (mm)

G_{mm} = theoretical maximum specific gravity

h_x = height after x gyrations (mm)

Calculation Example – (Corrected Relative Density)

The relative density at N_{ini} for the specimen in Figure 1

$$\%G_{mmx}@N_{ini} = \frac{2.409 \times 118.0}{2.461 \times 133.1} \times 100 = 86.78, \text{ say } 86.8 \quad 19$$

Where:

N_{ini} = 8 gyrations
G_{mb} = 2.409
G_{mm} = 2.461
$\%G_{mmx}$ = corrected relative density
h_x = 133.1 mm (height after x gyrations)
h_m = 118.0 (height of extruded specimen)

N_{ini} = 8
N_{des} = 100
N_{max} = 160

Figure 1 – Example Gyratory Printout 20

Specimen Size: 150 mm **Date: 11/01/04**
Pressure: 600 kPa **Time: 2:35:27**
Specimen ID: 1 **Test #1** **Technician:**

Specimen Height (mm) vs. No. of Gyrations

	0	1	2	3	4	5	6	7	8	9
0	150.9	146.0	142.4	139.9	137.9	136.4	135.1	114.0	133.1	132.4
10	131.7	131.0	130.4	129.9	129.3	128.9	128.5	128.1	127.7	127.4
20	127.0	126.6	126.4	126.1	125.8	125.5	125.3	125.1	124.9	124.7
30	124.4	124.3	124.0	123.9	123.7	123.5	123.4	123.2	123.0	122.9
40	122.7	122.6	122.4	122.3	122.1	122.1	122.0	121.8	121.7	121.6
50	121.5	121.3	121.3	121.2	121.0	121.0	120.9	120.8	120.7	120.6
60	120.5	120.4	120.4	120.3	120.2	120.1	120.0	119.9	119.9	119.8
70	119.7	119.6	119.6	119.6	119.5	119.4	119.3	119.3	119.2	119.1
80	119.1	119.0	119.0	118.9	118.9	118.8	118.7	118.7	118.6	118.5
90	118.5	118.4	118.4	118.4	118.3	118.2	118.2	118.1	118.1	118.1
100	118.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
120	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
130	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
140	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
160	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
180	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
190	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

21

Report

Report on standard agency forms. If applicable to the agency requirements, include the following information:

1. Project name
2. Test date
3. Sample or lot and sublot number
4. Test location represented
5. Specimen I.D.
6. Job mix formula I.D.

22

7. Percent binder to nearest 0.1%
8. Specimen mass to nearest 0.1g
9. G_{mm} to nearest 0.001
10. G_{mb} to nearest 0.001
11. Mold diameter to nearest 1.0mm
12. Height at each gyration to nearest 0.1mm
13. Relative density expressed as percent of G_{mm} to nearest 0.1%
14. Gyration angle to the nearest 0.01° and method used to determine or verify angle.

23

Tips!

- Don't forget to install base plate and paper disc in bottom of mold prior to filling.
- Don't forget to level the material in the mold.
- Cooling of extruded hot specimens is required in many cases to prevent damage due to handling.
- Don't forget to remove the paper discs as soon as possible from the hot specimens.

REVIEW QUESTIONS

1. What is the purpose of the Gyratory Compactor?

2. How many kPa's of pressure is applied to the specimen?

3. What angle is the specimen compacted?

4. Using the example information calculate the corrected relative density ($\%G_{mmx}$) at N_{des}.

PERFORMANCE EXAM CHECKLIST

GYRATORY COMPACTION OF HMA MIXTURES FOP FOR AASHTO T 312

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Aged mix brought to compaction temperature?	_____	_____
2. Base and upper plate of the mold heated to compaction temperature?	_____	_____
3. Paper disks placed on top and bottom?	_____	_____
4. Mix poured into mold all at once?	_____	_____
5. Pressure applied at 600 kPa ±18 kPa?	_____	_____
6. Specified number of gyrations applied?	_____	_____
7. Compacted specimen removed from mold and allowed to cool to room temperature?	_____	_____
8. Sample correct height at required gyrations (115 ±5mm)?	_____	_____
9. Corrected relative density calculated correctly?	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

_____

_____

_____

_____

Signature of Examiner _____

REDUCING SAMPLES OF HOT MIX ASPHALT TO TESTING SIZE FOP FOR WAQTC TM 5

01
02
03

Mix sample

Significance

Samples of bituminous paving mixes taken in accordance with the FOP for AASHTO T 168 are composites and are typically large in size. Materials sampled in the field need to be reduced to appropriate sizes for testing. As a general rule, field samples should be of a size that splitting once will result in the required test sample size. It is extremely important that the procedure used to reduce the field sample not modify the material properties.

Scope

This method covers the procedure for reducing samples of Hot Mixed Asphalt (HMA) to testing size. The reduced portion is to be representative of the original sample.

04
05

Quartered sample

Apparatus

- Flat-bottom scoop
- Broom or brush
- Non-stick splitting surface such as metal, paper, or heat-resistant plastic
- Large spatulas, trowels, metal straightedges, dry wall taping knives, or sheet metal quartering device
- Thermostatically controlled oven capable of maintaining a temperature of at least 110°C (230°F) or high enough to heat the material to a pliable condition for splitting
- Miscellaneous equipment including trowel(s),

spatula(s), hot plate, non-asbestos heat-resistant gloves or mittens, pans, buckets, and cans

06

Sample Preparation

The sample must be warm enough to separate. If not, warm in an oven until it is sufficiently soft to mix and separate easily. Do not exceed either the temperature or time limits specified in the test(s) method to be performed.

Overview

07

- Large Samples
- Method A: Loaf (Incremental) method
- Method B: Quartering by apex
- Method C: Quartering

Procedure

08

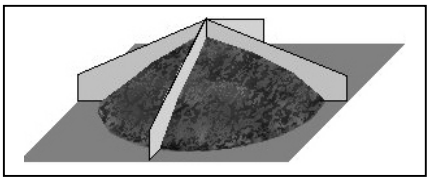
Large Samples, samples over 35 kg (75 lb)

1. Heat the trowel(s), spatula(s), and splitting apparatus to approximately 110°C (230°F).
2. Remove the sample from the agency approved container(s) by dumping into a conical pile on a surface where there will be neither loss of material nor the accidental addition of foreign material. The surface may be covered with heavy paper or other suitable material.

09

3. Mix the material thoroughly by turning the entire sample over a minimum of four times (see Note 1). With the last turning, form the entire sample into a conical pile. Mixing may be accomplished by turning the pile with a heated spatula or by rolling the material over with paper or other material used for the rolling surface. Make a visual observation to determine that the material is homogenous.

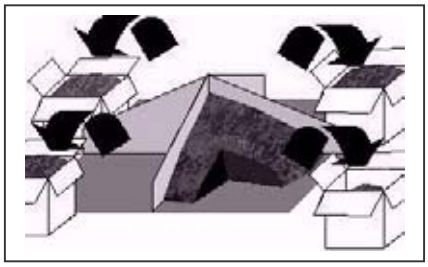
***Note 1*:** Some HMA mixes are prone to segregation; manipulation of the material should be minimized per Agency requirements.



10

Quartering Splitter

4. Flatten the conical pile to a uniform thickness and diameter by pressing down with a hot spatula or trowel. The diameter should be four to eight times the thickness.
5. Divide the flattened pile into four approximately equal quarters with a heated spatula, trowel, flat metal plate, or sheet metal quartering device.
6. Remove each quarter of the material and place in agency approved containers for testing, storage, or shipment. Mark containers per the Sample Identification section.



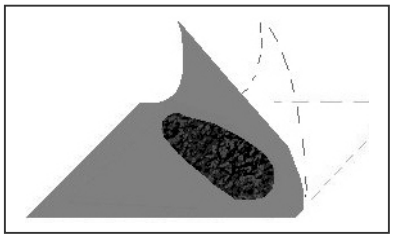
11

Placing into containers

7. Pay particular attention that excessive amounts of materials are not left on the splitting surface or splitting equipment.

12

8. When further reduction of the HMA is to be done at this time, reduce by using methods A, B, or C. A combination of the reduction methods may be used if allowed by the agency.

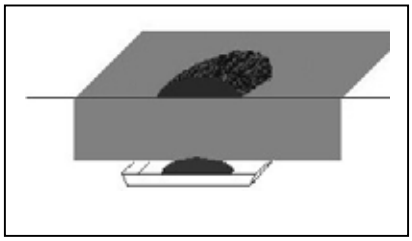


13
14

Mixing HMA

15
16

Mixing the sample



17

Material dropped into container

Reduction to Test Size

Method A (Loaf / Incremental) method)

1. Remove the sample from the agency approved container(s) by dumping into a conical pile on a surface where there will be neither loss of material nor the accidental addition of foreign material. The surface may be covered with heavy paper or other suitable material.
2. Mix the sample thoroughly by turning the entire sample over a minimum of four times. Alternately lift each corner of the paper and pull it over the sample diagonally toward the opposite corner causing the material to be rolled. With the last turning, lift both opposite corners to form a conical pile. Make a visual observation to determine that the material is homogenous.
3. Grasp the paper, roll the material into a loaf and flatten the top.
4. Pull the paper so at least ¼ of the length of the loaf is off the edge of the counter. Allow this material to drop into a container to be saved. As an alternate, using a straightedge, slice off approximately ¼ of the length of the loaf and place in a container to be saved.
5. Pull additional material (loaf) off the edge of the counter and drop the appropriate size sample into a sample pan or container. As an alternate, using a straightedge, slice off an appropriate size sample from the length of the loaf and place in a sample pan or container.
6. Repeat step 5 until the proper size sample has been acquired. Step 5 is to be repeated until all the samples for testing have been obtained.

Note 2 - When reducing the sample to test size it is advisable to take several small increments determining the mass each time until the proper minimum size is achieved. Unless the sample size is grossly in excess of the minimum or exceeds the maximum test size use the sample as reduced for the test.

Method B (Quartering by apex)

18

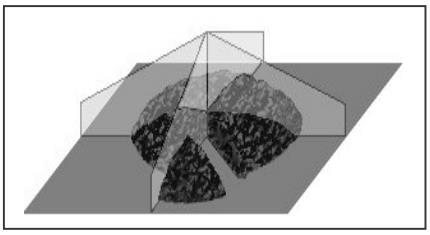
1. Remove the sample from the agency approved container(s) by dumping into a conical pile on a surface where there will be neither loss of material nor the accidental addition of foreign material. The surface may be covered with heavy paper or other suitable material.
2. Mix the sample thoroughly by turning the entire sample over a minimum of four times. Alternately lift each corner of the paper and pull it over the sample diagonally toward the opposite corner causing the material to be rolled. With the last turning, lift both opposite corners to form a conical pile. Make a visual observation to determine that the material is homogenous.

19

3. Flatten the conical pile to a uniform thickness and diameter by pressing down with a hot spatula or trowel. The diameter should be four to eight times the thickness.
4. Quarter the flattened pile using a quartering device or straightedge.
5. With the quartering device in place using a straightedge (taping knife) slice through the quarter of the HMA from the apex of the quarter to the outer edge. Pull or drag the material from the quarter holding one edge of the straightedge (taping knife) in contact with the quartering device. Two straight edges may be used in lieu of the quartering device.

20

6. Slide or scoop the material into a sample pan.
7. Repeat steps 5 & 6, removing a similar amount of material from the opposite quarter. Steps 5 & 6 are to be repeated until all the samples for testing have been obtained.



HMA from the apex of the quarter to the outer edge.

Note 3- When reducing the sample to test size it is advisable to take several small increments determining the mass each time until the proper minimum size is achieved. Unless the sample size is grossly in excess of the minimum or exceeds the maximum test size use the sample as reduced for the test.

21

Method C (Quartering)

1. Remove the sample from the agency approved container(s) by dumping into a conical pile on a surface where there will be neither loss of material nor the accidental addition of foreign material. The surface may be covered with heavy paper or other suitable material.
2. Mix the sample thoroughly by turning the entire sample over a minimum of four times. Alternately lift each corner of the paper and pull it over the sample diagonally toward the opposite corner causing the material to be rolled. With the last turning, lift both opposite corners to form a conical pile. Make a visual observation to determine that the material is homogenous.

22

3. Flatten the conical pile to a uniform thickness and diameter by pressing down with a hot spatula or trowel. The diameter should be four to eight times the thickness.
4. Quarter the flattened pile using a quartering device or straightedge.
5. Remove the opposite quarters saving the material for future use.
6. Repeat step 2 through 5 until the proper size sample has been achieved.
7. When additional test specimens are required, dump the removed material into a conical pile as in step 1 and repeat steps 2 through 6. This process may be repeated until sample has been reduced to testing size for all tests.

Sample Identification

1. Identify the sample as required by the agency.
2. Samples shall be submitted in agency approved containers and secured to prevent contamination and spillage.

Tips!

23

- Remember, the reduced sample must be representative of the whole.
- Proceed quickly so that splitting is done when the material is hot.
- Check agency requirements about what splitting device(s) may be used.
- With both methods B & C remember to combine opposite quarters or portions to produce a sample.

REVIEW QUESTIONS

1. Describe how the material is mixed before splitting.

2. What precautions must be taken with the tools used in splitting?

3. What type of equipment can be used to split a sample of bituminous mix?

4. How are methods A, B, & C different?

5. Can methods A, B, and C be used in combination?

PERFORMANCE EXAM CHECKLIST

REDUCING SAMPLES OF HOT MIX ASPHALT TO TESTING SIZE FOP FOR WAQTC TM 5

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Sample warmed if not sufficiently soft?	_____	_____
2. Trowels, spatulas, sheet metal quartering device (if used) heated?	_____	_____
3. Sample placed on non-stick splitting surface such as metal, paper, or heat-resistant plastic?	_____	_____
4. Sample mixed by turning over a minimum 4 times?	_____	_____
Method A		
5. Rolled into loaf and then flattened?	_____	_____
6. At least ¼ of loaf removed by slicing off or dropping off edge of counter?	_____	_____
7. Proper sample size sliced off or dropped off edge of counter into sample container?	_____	_____
Method B		
8. Conical pile formed and then flattened?	_____	_____
9. Diameter equal to about 4 to 8 times thickness?	_____	_____
10. Divided into 4 equal portions with heated spatula, trowel, thin metal plate, or sheet metal quartering splitter?	_____	_____
11. With two straight edges or a splitting device and one straight edge. Was one of the quarters split from apex to outer edge of material?	_____	_____
12. Similar amount of material taken from opposite ¼?	_____	_____
13. Cleared spaces scraped clean?	_____	_____
14. Process continued until proper test size is obtained?	_____	_____
Method C		
15. Conical pile formed and then flattened?	_____	_____
16. Diameter equal to about 4 to 8 times thickness?	_____	_____
17. Two diagonally opposite quarters removed?	_____	_____

OVER

18. Cleared spaces scraped clean? _____ _____
19. Process continued until proper test size is obtained? _____ _____
20. Opposite quarters combined to make sample? _____ _____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

Examiner Signature _____ WAQTC #:_____

Section 984
SAMPLING METHODS

All samples are obtained in accordance with the applicable specifications. When random selection is required, select sample times or locations in accordance with Section 981 and ASTM D 3665 Standard Practice for Random Sampling of Construction Materials.

984.01 COARSE AND FINE AGGREGATE

Refer to AASHTO T 2: Standard Practice for Sampling Aggregates**.**

984.02 SAMPLING BITUMINOUS PAVING MIXTURES FROM BEHIND THE PAVER

984.02.01 Scope

This method covers sampling bituminous paving mixtures from the roadway behind the paver prior to compaction. Samples obtained by this procedure may be used for acceptance and quality control of materials whose point of acceptance is from the grade prior to compaction such as Hot Mix Asphalt.

984.02.02 Apparatus

1. Square mouth shovels
2. Trowel and scoops
3. A single metal plate with two feet minimum width and sufficient length to hold required sample size. The plate shall have a wire attached sufficient in length to extend beyond the edge of the mat.
4. Cookie cutter sampling device, square sampling template constructed from formed steel angle with two handles, device shall be sized to fit over metal plate without extending beyond it. (Optional)
5. Containers such as cardboard boxes, heat resistant buckets, and insulated containers.

984.02.03 Sample Size

Sample size depends on:

1. The test methods to be performed.
2. Number of labs performing testing
3. Project specification

984.02.04 Procedure

1. Coordinate sampling with paving crew and paving operator, ensuring safety.
2. Place the sampling plate longitudinally on the roadway ahead of the paver at a pre-determined random location.
3. Run the attached wire perpendicular to the direction of the paving operation, beyond the farthest auger extension and/or ski. Keep wire taut and on the ground to prevent snagging the auger extension and/or ski.
4. Allow the paving operation to run without interruption.
5. When the paver has passed over the plate, pull the wire to locate plate perimeter. (If the paver shifts the plate such that there is bituminous material under the plate, remove plate and start over.)

6. With plate still in place, remove full depth of bituminous material from the plate. Care should be taken to prevent sloughing of material. Optional use of cookie cutter: Place the sampling device over the plate, press device through material, and remove all material inside the sampling device.
7. Deposit bituminous material in suitable container; prevent contamination and segregation of material.

984.03 SAMPLING BITUMINOUS MATERIAL FROM A WINDROW

984.03.01 Scope

This method covers sampling bituminous material such as Hot-Mix Asphalt (HMA) from the windrow at the job-site. These samples are to be utilized for Hamburg Wheel Track Testing only. Materials Manual Part 8 Section 990.

984.03.02 Apparatus

1. Square mouth shovels
2. Containers such as cardboard boxes, heat resistant buckets, and insulated containers

984.03.03 Procedure

1. Choose a location along the windrow that appears uniform; avoid the beginning or the end of the windrow section.
2. Remove approximately 1 foot from the top of the windrow.
3. Bench out a section at an intermediate height on each side of the windrow.
4. Obtain one increment of the sample from the top of the windrow.
5. Obtain two more increments from the benched sections.
6. Deposit bituminous material in suitable container; prevent contamination and segregation of material.

984.04 SAMPLING BITUMINOUS MATERIAL FROM TRUCK TRANSPORTS

984.04.01 Scope

This method covers the UDOT modifications to AASHTO T 168: Sampling of Bituminous Paving Mixtures, when sampling bituminous mixtures whose point of acceptance is the plant from the transport unit such as Open-graded Surface Course (OGSC) and Bonded Wearing Course (BWC).

984.04.02 Apparatus

1. Square mouth shovel,
2. Square mouth scoop
3. Thermometer with a range of 100 to 400ºF,

4. Stainless steel bowl or pan of sufficient size for sample to be obtained

984.04.03 Procedure

1. Follow AASHTO T 168: Sampling of Bituminous Paving Mixtures Section 5.2.2 *"Sampling from Truck Transports"* with the following modifications: Sample may be obtained in a single increment.
2. Sample may be obtained at test sample size or larger and reduced to test sample size according to 8-985. (Refer to test method to be performed for sample size, i.e. T 308: Determining the Asphalt Binder Content of Hot-Mix Asphalt by the Ignition Method would require a 2000 g sample for ¾" Nominal Maximum Aggregate Size material).
3. Determine the temperature of the material in the same location sample was obtained.

984.04.04 Alternate Procedure

For sampling when the above procedure is deemed unsafe.

1. Fill a loader bucket from the hopper.
2. At a safe location, perform steps 2 and 3 above.
3. Remaining material in the loader bucket shall be loaded onto transport for delivery to job site. (Remainder of truck transport may be loaded from the hopper before, or after sample is obtained.)

984.05 SAMPLING BITUMINOUS MATERIAL AFTER COMPACTION (OBTAINING CORES)

984.05.01 Scope

This method covers the UDOT modifications to AASHTO T 168: Sampling of Bituminous Paving Mixtures, when obtaining test specimens (cores) of compacted bituminous material.

984.05.02 Apparatus

Core drill with a diamond cutting edge.

984.05.03 Procedure

Follow AASHTO T 168: Sampling of Bituminous Paving Mixtures Section 5.2.6 with the following modifications:

1. Sample may be obtained in a single increment.
2. Sample location is randomly selected in accordance with Section 981, ASTM D 3665 Standard Practice for Random Sampling of Construction Materials, and the Specifications under contract.
3. Party identified in the specification marks sample location. Sample shall be obtained within 6" of the marked sample location.
4. Samples obtained for in-place density and/or thickness shall be 4" diameter cylinders. Samples shall be obtained prior to traffic being allowed on the pavement. Care shall be taken not to damage specimen, damaged density specimens shall be discarded.

Replacement specimens shall be obtained within 1 foot of original location.

984.05.04 Transporting Cores

1. Transport cores in containers that prevent damage from jarring, i.e. dropping, rolling around, hitting together and/or impact with any object.
2. Prevent cores from freezing prior to testing.
3. Protect cores from excessive heat (130° F) prior to testing.
4. Damaged cores will not be used for acceptance tests.

Section 985
SAMPLE REDUCTION METHODS

985.01 Scope
This procedure covers the reduction of large samples of bituminous paving mixes, including hot mix asphalt (HMA), stone matrix asphalt (SMA) and cold mix asphalt field samples to the appropriate size for testing. These techniques are intended to minimize variations in measured characteristics between the test samples and the larger sample.

985.02 Procedure
Utilize AASHTO T 248; Reducing Samples of Aggregate to Testing Size with the following modifications:

Method A- Mechanical Splitter
Method A is the preferred method of reduction for dense-mix HMA.
Add to section 7 Apparatus

- Cooking spray
- Oven: capable of heating sample to a temperature sufficient for sample to be pliable
- Heat resistant gloves.
- Any convenient method for heating splitter and splitter pans in a manner that does not damage apparatus
- A non-contact temperature device such as an infrared temperature gun.

Add to the beginning of Section 8 Procedure:
If the sample does not separate easily, warm the sample in the oven (230° F max) until it can be mixed and separated (not to exceed 2 hrs).
Splitter and splitter pans may be heated, not to exceed 230° F, as determined by a non-contact temperature device; splitter may be sprayed with a light coating of cooking spray, if necessary, to keep fines from sticking to the splitter.

Method B –
Method B may be used for reduction of field samples of SMA or Open-Graded Seal Coat (OGSC) and other bituminous mixtures whose point of acceptance is the plant from truck transports.
Add to section 9 Apparatus:

- Oven: capable of heating sample to a temperature sufficient for sample to be pliable
- Heat resistant gloves
- Do not use canvas blanket for SMA or OGSC

Add to section 10:

If the sample does not separate easily, warm the sample in the oven (230° F max) until it can be mixed and separated (not to exceed 2 hrs). Tools may be heated, not to exceed 230° F.